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ABSTRACT

This document contains the full text of 21 papers presented at an international conference on Girls And Science And Technology (GASAT). They include: "Women in Science and Engineering: A Case of Awareness and Encouragement" (Mary Anderson); "A Multi-phased Program for Recruiting Southern Women into Science Based on Extensive Media Use and Interaction with Suitable Role Models" (Ruth Cade and Robert Cade); "Project Seismic" (Deanna Chitayat); "Loughborough University Women in Engineering Project" (G. E. Chivers); "The Science Education of Girls in Canada: A Strategy for Change" (Janet Ferguson); "To Attract and Hold Young Women's Interest in the Physical Sciences (So That They Can Achieve Success Equal to That of Young Men)" (Lucile Fink); "Report of Science Examinations and the Type of School" (Jan Harding); "Consequences for Science Education Based on Results of Girls' Learning Interest" (Lore Hoffman); "A Description of the Science Career Workshop Project for Women in Science" (Don Low); "Girls and Physics Textbooks in the HANDROVER-Project" (Ilja Mottier); and "The CHANGING ATTITUDES Project" (Isabel Romao). Additional papers on related topics are by Carol Niznik, Ineke de Raaff, Jan Raat, Doris Simonis, Barbara Simpson, Svein Sjoberg, Barbara Smail (with Judith Whyte and Alison Kelly), Gerrit Verkerk, Mathieu Dumont, and Lena-Pia Lindholm. (JN)

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PREFACE

The first international GASAT-conference
(GASAT = Girls And Science And Technology)
was held at the Eindhoven University of Technology (THE)
in Eindhoven, The Netherlands, November 9 - 13, 1981.

This volume 2 *CONTRIBUTIONS* contains the full text of the papers brought in by the participants to serve as a basis for the discussions. Most of the papers are reproduced in the way they are received. The reader may excuse some minor language or typing mistakes.

The editors felt it important to publish the available material and thus to make it more accessible to the growing number of persons concerned about promoting education in science and technology for young girls and women in various countries.

A short report of the conference is published in *PROCEEDINGS GASAT CONFERENCE 1981*, vol 1.

Volume 3 in this series, *GIRLS AND SCIENCE AND TECHNOLOGY, GASAT-conference 1981* presents backgrounds of the problem, information about the structure of different educational systems and the place of science, and an outline for the future.

The editors

Eindhoven University of Technology,
December 1981.

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1. WOMEN IN SCIENCE AND ENGINEERING: A CASE OF AWARENESS AND ENCOURAGEMENT

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In the United States, approximately one-third of the students entering medical, law and business schools are now women. Fifteen years ago only one-tenth of the entering students in these professional schools were women.[3] Young women in great numbers are expanding their horizons and entering these formerly almost exclusively male dominated professions. Although the percentage of women entering fields in the physical and engineering sciences has increased in recent years, the numbers are not nearly as large as those of the women enrolling in the aforementioned professional schools. Science careers are apparently not considered attractive or perhaps not even considered by most young women.

The lack of adequate numbers of scientists is a significant problem with grave consequences for any nation. Women remain the largest untapped source of supply for this demand. In addition, women have the potential to contribute a perspective which differs from the male dominated world of science.[2] We need to change the image of science as an inhospitable and unattractive environment for women[3] and need to insure that science is a viable career option for women. Finally, we need to understand the career decision-making process of teenage women.[3]

As a child, I was aware of three career options for a woman: nurse, secretary and teacher. Through a process of elimination, by age 7, I had made teaching my career choice; the subject to be decided later. At the encouragement of a high school mathematics teacher, I took a third year of mathematics and then realized that I had always enjoyed the subject. After majoring in mathematics in college, I chose statistics as the major area for the Ph.D. degree because of the influence of the major professors in that field.

I am now an Associate Professor of Engineering, the only woman faculty member in the School of Engineering at Arizona State University (ASU). I am convinced that engineering in general, and industrial engineering in particular, are excellent fields of study for women. I have spoken to high school women and women interested in a reentry program. The response of these women to the possibility of entering the field of industrial engineering has been most enthusiastic. Wells cites that the lack of women in engineering is due to the lack of information and their own lack of self-confidence to succeed.[11] I am convinced that the primary causes for the dirth of women in industrial engineering or any area of engineering, is the fact that they have not been made aware of the opportunities nor been encouraged to prepare for and persevere in such a career.

In my experience women in general have a very limited knowledge of the possible careers in engineering and almost no knowledge of industrial engineering. Furthermore, they have never associated themselves with such a career. After viewing a role model and considering options within the field of engineering, many young women then choose to go into engineering. Although television programs feature women doctors and lawyers and women in business, the star of the show is seldom a woman engineer or physicist. I believe that the lack of awareness among young women of careers in industrial engineering parallels the lack of awareness of careers in physics and technology. Common to these career paths is the need for a good foundation in mathematics. The techniques discussed in this paper for increasing the number of women in engineering can readily be applied to increasing the number of women in science and technology.

Jewell Plummer Cobb[2] has a theory about the participation of women in science called "Female Filters in Science." This author believes that there are important filters present in the life of a young woman who aspires to be a scientist. These filters for men are either nonexistent or contain pores of a larger size. Some of the filters are associated with the field of mathematics. For completeness, a summary and discussion for this article follows.

The first two filters include a lack of awareness and positive association with science and mathematics. A socialization process begins at birth with pink blankets and dolls for female babies. The first filter occurs during the infant and pre-school period. During this period boys receive chemistry sets, erector sets, trucks and games geared to large muscle development and to association with science. During the elementary school years a second filtering away from science takes place. Mathematics is classified as a male subject. This classification is strengthened by elementary school teachers, the majority of whom are women, who are rarely comfortable with mathematics.

The third filter is the junior high and high school experience. In a study by the National Assessment of Educational Progress, girls and boys performed equally on mathematics and science achievement tests at age 9. At ages 13, 17, and 26 to 35, however, males performed increasingly better than females. As girls proceed through school they are subject to pressures to conform to societal expectations which do not usually include mathematics and science as appropriate fields of study for females. In mathematics, the father usually becomes the authority as the child progresses from sixth grade through high school. Studies have shown that girls were twice as likely as boys to conclude that a poor grade in mathematics was due to a lack of ability rather than a lack of effort.

The high school years are the most critical. College-level mathematics is a prerequisite for mathematics, science and engineering majors. However, women students experience a lack of encouragement by family, counselors and society to continue their studies in mathematics. A high school counselor told me a few years ago that he only encouraged *boys* to take two years of mathematics and was very surprised when I suggested that boys *and girls* should be encouraged to take *more* than two years of mathematics in high school. Girls are nine times less likely than boys to have good mathematical preparation for college.

The fourth filter, college, is also usually a period of lack of encouragement for girls who have the ability to major in science. Some well-meaning advisors feel that it is too difficult for women to enter and survive in heavily male dominated fields. Some male advisors do not want to see women enter "their" domain. Mothers may tell their daughters that they will never marry if they choose a career in which they will be competing with men. Cobb feels that the decision to be a science major in college requires strong motivation and independence, characteristics expected and developed in precollege years in males.

The fifth filter of graduate school may also be characterized by a lack of encouragement. The senior science researcher, in a period of scarce research funding is inclined to invest his time and effort on a male student rather than a female, whom the researcher feels may marry, have children and leave science. A sixth filter centers on the senior scientist or advisor who may control development of the dissertation, its acceptance and publication, referrals, post-doctorate job placement and career progression.

A seventh filter for women after formal schooling includes a "superwoman" dilemma. She often must be career woman, wife, mother and homemaker all at the same time. Cobb reminds us that to survive, women who choose the role of homemaker and scientist or engineer need a supportive husband and adequate child care arrangements.[7] My own husband, a Professor of Mathematics, certainly plays a very supportive role in my career. There is a need for more part-time positions for women scientists to supplement the child care. I was fortunate to be able to survive in academia in spite of working part-time for 12 years while my boys were young. A final observation is that women scientists on the campus are underrepresented in tenured positions at top universities where major research is conducted. The "good old boy network" is still very much alive.[8]

I suspect that this filtering system is becoming more porous, especially at the college and graduate level. In addition, programs such as the Women in Science program of the National Science Foundation have been developed to enhance opportunities for women in science. These programs, through workshops and career facilitation projects, are attracting greater numbers of women to science and helping them to prepare for a career in science. The workshops give science career information to high school and college women as well as women interested in reentry after a career interruption.

Those women who were filtered out of science have a second chance in some science career projects. I am the Project Director of a National Science Foundation supported science career facilitation project. I am currently accepting applications to a reentry program for some thirty women who have held their last degree for at least two years and are unemployed in a technical field or are underemployed in terms of their potential. Although an undergraduate degree in a science field is preferred, applicants are being considered with non-science degrees. In similar programs highly motivated women with non-science degrees have proved that they can succeed in a science reenty program. In my particular program, a Master of Science degree can be earned with a major in Industrial Engineering and concentrations in information systems or organizational control. This fast track program of 15 months features registration fee waivers, a professional development seminar and paid half-time industrial internships. A year of Calculus is required as a program prerequisite.

At the time of this writing, close to 90 women have inquired seriously about the program and it is expected that most of these women will apply. Many of these women, especially biology and non-science majors, have not had Calculus, but are taking it this school year in preparation for the program. Since they acquired their degrees many of these women have been introduced to the computer and are very interested in learning more. With this awareness, they now have the motivation to take another year, or even more, of mathematics to enable them to pursue this new interest. Many of these women studied traditional "female" fields only to find no employment in their field or that the available jobs were not demanding, rewarding, nor well-paid. To avoid ill-chosen fields of study or at least to enable a woman to make a career choice fully aware of the options and possible consequences, programs of awareness of career options must begin in high school, junior high and even grade school.

The last two years of high school may not be too late to encourage women to consider engineering as a career. In a study by Len[8], it was reported that although most men majoring in engineering in college had decided to do so by their freshman year in high school, most of the women engineering majors had chosen their field of study during their senior year in high school. While the mathematics required for science and engineering majors can always be made up upon entering college, to facilitate career options in science and engineering, girls should be encouraged while in junior high to take three or four years of mathematics in high school. To offset the women grade school teachers who are uncomfortable with mathematics, girls in the grades need to be exposed to positive science and engineering role models and told that it is "OK" to study science and mathematics. At a minimum they should be made aware early that by avoiding science and mathematics courses or by taking the lowest level of such, they may be decreasing their options of a career choice at a later date.

Young women need to be told that engineering (science or technology, as the case may be) is no longer nearly closed to women. Industry is now actively seeking women engineers and myths about the engineering profession are disappearing. In a recent study by the Department of Education and the National Science Foundation entitled, "Science and Engineering Education for the 1980's and Beyond," three fields were identified in which severe manpower shortages could develop by the end of the century: computer specialists, industrial engineering and aerospace engineering. In this study industrial engineers stood out as members of the engineering profession with the widest gap between the number of graduates and the number of job openings: 96% more openings expected than IEs being graduated! Women are needed to help fill this critical shortage in personnel.[1]

In addition to general job availability information, young women need to be made aware of career options in industry, government, laboratories and academia. For example, currently in the United States there are more than 2000 open faculty positions in Engineering schools. Young women need to be encouraged to consider teaching at the college level in engineering as a viable career. An academic career usually does not preclude the freedom to pursue individual interests and is very compatible with the raising of a family since vacations and summer breaks usually coincide with those of the children's school year. Young women need to be made aware of the various areas of concentration within a general field, as well as salary and job location information. A woman role model who finds her career in engineering or science demanding and rewarding can be very effective in encouraging young women to consider her field as a possible future career.

There are also misconceptions that need to be put to rest. One of the myths for engineering is that engineers work mostly with things, e.g. concrete and steel, as opposed to people. However the fact is that most engineers devote a major portion of their careers and their daily activities to communicating, getting along with, and helping other people.[5] Since Industrial Engineering is the branch of engineering most concerned with people oriented systems, industrial engineers, especially, spend a major portion of their time with people.

A second myth is that an engineering curriculum is unsuitable or too strenuous for a woman. Women students achieve in an engineering curriculum as well as men even if they haven't built model airplanes or taken apart lawn mower engines. Engineering is so broad today that many competent engineers don't have hands-on experience with engines or motors or farm machinery.[5]

A third misconception is that you have to *like* mathematics to go into engineering. An enthusiastic attitude toward mathematics will probably make pursuing a career in engineering more pleasant, but it is not necessary. Most of my statistics students in Engineering do *not like* mathematics and statistics, however they realize that they have to take these courses in order to study and to work in the areas of engineering they will enjoy.

One more myth is that engineering students have such a stringent class and laboratory schedule that they don't have time to enjoy college life. Most engineering students find that their schedule is interesting, rewarding and demanding, but there is still some time for a social life.[4] The "career/family conflict" myth can be answered by the fact that approximately seven out of every ten women in engineering are married and most of them have children.[4] Incidentally, one study showed that half of the recently graduated married women engineers are married to engineers.[10] And as more women enter the predominantly male field of engineering, they are finding less problems on the job due to sex stereotyping. One practicing woman engineer stated: "Working with all male engineers seems to pose no more problems than it did in school. Engineers in general are some of the most even-tempered, steadiest people whom I have met. They treat you according to the caliber of engineer you are. Tact, understanding and patience are traits that stand women in good stead."[4]

We need then to make women aware of engineering (or science or technology) as an appropriate and appealing career choice, and to encourage them to prepare for, to pursue and to persevere in such a career choice. But how can we make high school women aware of engineering (or physics) and encourage them to consider a career in the field? Most high schools do not have a course in engineering, although some may have a course in electronics. Most high schools include physics in their curriculum. A young woman would usually need some positive encouragement to take electronics or physics: to increase her options or to prepare for a chosen career. Exposure to the subject however is not adequate. I took Physics in high school and for four semesters in college, enjoyed the courses, but still have very little knowledge of the careers available for physics majors other than in academia. The physics teacher, at a minimum, if not a woman enthusuastic about the field of physics, should invite a woman physicist to address the class and tell about her career and other career options in physics.

We at Arizona State University are involved in an expanding program to recruit high school students to the College of Engineering and Applied Sciences. This fall the third annual Scholastic Competition and Design Contest will be held on campus to attract top students through a mathematics and science oriented examination contest and design competition. Last fall thirty-four schools were represented and 300 students participated in one or more events. The examination areas were Mathematics, Algebra I and II, Trigonometry, Engineering Graphics, Chemistry, Physics, and Calculator. The design competition included a bridge, a protective egg container (tested by dropping from several stories high onto concrete), and a candle-powered car. Engineering and Applied Sciences faculty monitored the contests and competition. As an exam proctor, I used the opportunity to encourage the women especially to take all the mathematics that they could in high school to increase their options and to consider engineering as a career.

The event was sanctioned by the Arizona Interscholastic Association and students competed in three school categories: (1) AAA; (2) AA; and (3) a combination of A, B, and C. Awards for first, second and third places were presented for all examination and design areas in the three school categories. The school with the largest number of winners in each of the three categories was presented a trophy.

The cost of the medals and trophies accounted for the largest single expenditure. The Papago section of the Arizona Society of Professional Engineers donated $300 to help defray expenses. The Arizona Section of the American Chemical Society assisted in the preparation of the Chemistry exam.[7]

On March 20, 1981, the second Mathematics-Science Teacher Workshop designed to provide mathematics and science teachers with information on all programs offered by the College of Engineering and Applied Sciences was conducted. Eighty-nine teachers from 42 different secondary schools were present. A panel of students participated in the program and responded to questions. The student panel was mentioned most often in the end of workshop questionnaire as a beneficial part of the program. A similar workshop for principals and Board of Education members was suggested and received unanimous support from the participants.[7]

Mathematics and science high school teachers would do well to invite college students in their area to speak to their classes. Some of our women engineering students routinely return to their secondary alma mater and speak to mathematics and science classes. Although women students particiapted on the panel, this workshop did not give any special emphasis to potential women engineering students. My participation as a woman in engineering is planned for the next workshop to suggest that women mathematics and science students need to be made aware of the opportunities for women in engineering and to be encouraged to pursue such careers.

For four years a High School Summer Institute has been conducted by the College of Engineering and Applied Sciences. During the summer of 1981 a series of four programs designed to increase the number of minority group students in engineering was held. The program was organized into four separate one week sessions to bring the following minority high school students onto campus for an orientation and introduction to engineering: (a) Native American; (b) Gifted; (c) Women; and (d) Hispanic/Black. It should be noted that women participated in all four weeks of the institute.

A total of 91 high school students participated, 57 of them women. The students were introduced to the various fields of engineering, listened to appropriate role models from industry and academia, toured the engineering laboratories, and were taken on tours of local industrial facilities. The program was financially supported by contributions from Arizona industries totalling $28,000. Out of town students were housed on campus for the week. The program was advertised through the mathematics and science high school teachers. The number of students enrolling in engineering at the college level after attending this institute is over 50%.[7]

I am a regular speaker during the weeks for women and the gifted students. The institute week for women includes as speakers practicing women engineers and women engineering students representing different areas of engineering. The high school women are very interested in information on career/family balance and treatment in a male-dominated field, as well as the opportunities and salary levels for women engineers. Again I urge the women to take as much mathematics as possible to increase their options for a career. Also at this institute the women hear about Industrial Engineering, often for the first time.

Most of the women are surprised to learn that Industrial Engineering is the branch of engineering most concerned with people oriented systems and that thus Industrial Engineers are a prime source of technical management talent. Very few engineering managers are women. It is therefore important for women to know that if they choose the organizational control concentration in Industrial Engineering they will be exceptionally well prepared to compete for management positions. These high scool students are also informed that even if they do not major in engineering at the undergraduate level, they can obtain a Master of Science degree in any engineering discipline after completion of some deficiency work. This exposure should help to increase the number of students, specifically women, in engineering.

The College of Engineering and Applied Sciences recently hired a full-time person to engage in activities to identify, recruit , enroll, retain, and graduate minority students. The tasks of this Minority Coordinator include facilitating the flow of information to minorities, visiting high schools and community colleges, organizing and running the High School Summer Institute and other special institutes, developing financial support for both minority students and programs, and counseling and advising minority students. Women are included in the definition of a minority, and although most of the efforts of this office thus far have been directed at ethnic minorities, it must be noted that minority women are being recruited and served by this office. In fact, many of the applicants for the scholarships designated for minority engineering students have been women. This past year $35,000 was awarded to minorities through the University Industry Program administered by the Financial Aids Scholarship section and by the School of Engineering. The announcement of these scholarships to the high school students visited by the Minority Coordinator is an effective recruiting tool.

An additional recruitment incentive used by the School of Engineering is a Cooperative Education Program initiated in September 1979. Undergraduate students are given the opportunity to interrupt their studies for a work period to gain hands on experience in engineering and to help finance their education. The first work period was from January to July 1980. During the Fall 1980 (July to December 1980) 14 students were placed with local industrial companies. In the Spring 1981 (January to July 1981) 25 students participated. Five of the 25 Spring 1981 students were returning for their second coop work experience.

The students have been placed with 22 cooperating companies. Twelve of these companies have received more than one student during a work term or have had a student return for their second work period. Salaries for the students ranged from $700 to $1300 per month. Comments from the students and their immediate supervisors in the companies have all been favorable and supportive of the Cooperative Education Program.[7]

Our Graduate Engineering Minority Program is one more example of a program that can aid in recruiting minority women. ASU was accepted as one of 25 universities awarding graduate engineering degrees for a program in which qualified junior minority engineering students are employed during the summer at a participating company and upon acceptance by a graduate college, receive a stipend of $4,000 per year and paid tuition and books to complete a graduate degree. One ASU student has been accepted into the program and four students from other participating member universities have applied for admission to the engineering graduate program at Arizona State University.[7]

The Admissions Offices of the three state universities in Arizona have organized a state-wide workshop for high school counselors each year. The workshop location is rotated among the three campuses. During this all day workshop, a representative from the College of Engineering and Applied Sciences gives an hour presentation to the counselors on all the engineering programs and their basic prerequisites. It is hoped that this type of information is then translated into informed counseling and that any student considering a mathematics, science or engineering career will be encouraged to take as much science and mathematics as the student's program allows.

Other universities and professional organizations use other techniques for educating and encouraging young women concerning scientific and technical careers. For example, the College of Engineering at the University of New Mexico established an Engineering Program for Women in 1977. The objectives of this program include providing current students with information on scholarships and job opportunities, and working with high schools to provide information on opportunities for women in engineering. This center has produced an attractive four page brochure for distribution to high school women. The brochure contains information on women as engineers, typical job situations, needed skills, myths about women in engineering and what engineering has to offer as well as specific information on the engineering program at UNM.[4]

Another example worth noting is the Women in Science and Engineering Network (WSE) in New Mexico: a non-profit association of scientists, engineers, educators, parents, community leaders, and business and industry people. Network members work to develop and conduct innovative mathematics and science education programs for young women. As early as 1974 WSE founders were developing programs to encourage the participation of women in science and engineering. In 1979 WSE began the Visiting Women Science Program in which members visit midschools to discuss their work in science and or engineering, the rewards of such careers, and the preparation necessary.

In March, 1980, WSE along with help from local industry, school districts and national corporations, sponsored career awareness conferences (called Expanding Your Horizons) for high school women. The objectives of these conferences were to provide career information, hands on activities related to specific career options, and models of successful women involved in nontraditional employment. Over 500 young women have attended these conferences which involved over 300 professional women.[6]

The Society of Women Engineers (SWE) is a professional, non-profit, educational service organization of graduate engineers, and men and women with equivalent engineering experience, dedicated to the advancement of women in the engineering profession. It is a national organization with international membership numbering in the thousands. One of the objectives of the Society is to inform young women, their parents, counselors, and the general public of the qualifications and achievements of women engineers and the opportunities open to them.

One chapter of SWE annually holds an all day Saturday conference for high school women to acquaint the women with the opportunities available through a career in engineering and to encourage them to consider such a career for themselves. Other SWE chaper projects include high school visitation programs and volunteer work with the Girl Scouts of America. In this last project, women engineers work with girl scouts on career badges in engineering. This is an example of an excellent opportunity to work within an existing organization to educate girls about engineering.

Our local Southwest Chapter of SWE is a prime source of speakers for the High School Summer Institute held at our University and for the student chapter of SWE on campus. This chapter also helps provide judges for the semi-annual Science Fair held by the local junior and senior high schools in which students submit a scientific exhibit and report. Our SWE chapter donates and awards a trophy to a young woman in the competition to increase the awareness of women about engineering.

The national organization of SWE includes financial aid for freshman women entering engineering school in its scholarship program. Both the national and local organizations award scholarships to encourage the retention of women enrolled in engineering programs.

Representative of the professional organizations for each discipline within engineering is the American Institute of Industrial Engineers (AIIE). The local chapter of this organization has a high school visitation program also. AIIE members visit with high school counselors and high school students and leave literature on the field of Industrial Engineering which includes the high school preparation necessary for study at the college level.

Our Department of Industrial and Management Systems Engineering also makes high school visitations on an individual basis, usually speaking to mathematics classes. An example of the impact of such presentations is found in one of our current women industrial engineering senior students. She attended a presentation made by my chairman and me. This young woman liked mathematics, but did not want to teach. Her counselors had not been able to help her. When she heard about the people oriented field of Industrial Engineering from my chairman and heard my suggestion that Industrial Engineering was an excellent choice of a career for a woman who liked mathematics, she made a career choice for Industrial Engineering.

Some high schools have their own career programs. I participated in a Mathematics Career Day for women held by one high school. All of the women students enrolled in mathematics classes were released for the day to attend the conference. Male students also attended segments of the program during their free hours. The purpose of the program was to inform the young women of the role and importance of mathematics in various career options. Women role models addressed the entire assembly. Several small group discussions followed.

In another local high school, the top women enrolled in mathematics and science are excused from their classes once a month to attend a Career Seminar. I spoke to this group of women on engineering in general, on industrial engineering in particular, and on my own experiences as a woman engineering professor with a family. I also stressed to them the importance for me to keep a balance between the spiritual, career, family and recreational (golf and running) spheres of my life. At the end of my seminar, over half of the women indicated that they were considering engineering as a career choice.

An additional avenue for increasing the awareness of engineering as a career for women has been afforded me through invitations to speak to professional organizations. As an example, I made a presentation to a Regional Conference of Community College counselors and mathematics instructors. The opportunities for women in engineering and the importance of a good mathematics preparation for such a career was of extreme interest to the participants. The value of encouragement by a mathematics instructor was also stressed. I was told by a female graduate student in engineering, "Because I see that you as a woman have made a career in engineering, I have the courage to continue my studies."

Evidently some of our programs of awareness for the College of Engineering are working. The freshman engineering class at ASU is now approximately 20% women. *The number of female engineering students at ASU has risen 300% since 1977.* Opportunities for women for a career in science and engineering have never been better. We just need to broadcast this message and to encourage women to prepare and to persevere.

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2. A MULTI-PHASED PROGRAM FOR RECRUITING SOUTHERN WOMEN INTO SCIENCE BASED ON EXTENSIVE MEDIA USE AND INTERACTION WITH SUITABLE ROLE MODELS

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INTRODUCTION

This paper will discuss several projects and research studies which the authors have conducted. All of these projects have been effective in encouraging, either directly or indirectly, regional women to choose educational programs which lead to careers in science. The first author is a native of the region and holds a Ph.D. degree in Engineering Mechanics. She received all of her education in the local public school system and in universities located in the South. She presently serves on the faculty of the Department of Computer Science and Statistics and directs the high school recruitment for that Department. The second author, Dr. Robert Burr Cade, has extensive experience in mass media and is a faculty member in the Department of Radio, Television and Film. Both authors are employed at the University of Southern Mississippi which is near the coastal region of the state. Their diverse backgrounds and experiences have enabled them to design projects for recruitment of women into the sciences which have a much broader scope than projects designed primarily by scientific personnel.

The results of several studies conducted in connection with these projects will be presented. Demographic characteristics of 270 regional women planning to enter scientific fields will be presented. Enrollment figures for the Department of Computer Science and Statistics will be presented for the years 1975-1980. Results of sex-role identity studies of regional women choosing careers in science are presented.

In the following sections, several factors which influence the design of an overall recruitment program will be considered. Although all of the factors which influence career choices of women appear to be interrelated, each section will describe one phase of the overall program and point out factors which are considered to be important in the design of that particular phase of the program.

DESCRIPTION OF THE RECRUITMENT PROGRAM

Determining the Characteristics of the Target Group

Although it might appear that a successful recruitment program in one region should produce success in any geographical area, the authors believe that careful study of the demographic characteristics of the target population is essential. The target group in the program discussed in this paper is comprised of the women of the southern region of Mississippi, although some projects have been state-wide in scope.

Mississippi is an economically deprived state with over 25 percent of its population living in families with incomes below the poverty level. It has a high rate of unemployment (7.4 percent) and a low average level of formal education (median, 10.7 years.) The state's population is 37.2 percent black and 55.5 percent of its people live in rural areas.[1]

The social structure of the region is based on an agrarian economy, which produced strong and large family units. Family ties are a primary factor in the development of acceptable social behavior. Women in the South have been more reluctant to leave the home and enter the labor market than their counterparts in other geographical areas. However, a recent increase in industrial development and a changing population--caused by a rapid influx of people from harsher climates--is affecting changes in the traditional social and economic structure of the state. Large family units are dissolving as young people move to find employment, since the family farm can no longer support several generations.

In the past, the education of young women in the South has been planned around a life spent as a homemaker. Prevailing societal attitudes toward career women serve to discourage young women from selecting a career in science. The low level of formal education of the general population also proves to be a mitigating factor in the motivation of young women to obtain higher education. Most high school counselors and many high school teachers have no background in science; and, consequently, they tend to steer their own students--particularly young women--away from science and mathematics courses.

A paucity of women in educational programs leading to careers in science is understandable when they grow up in an environment almost hostile to changes in the traditional roles of women. However, a knowledge of the societal attitudes, family influences, economic pressures and educational environments to which young women are exposed should be acquired before a program is designed for recruitment.

Developing Contacts in Regional High Schools

Programs designed to provide interaction among scientific academic personnel are effective in developing contacts within the high schools. The authors have conducted two summer workshops, sponsored by the National Science Foundation, for teachers of science and mathematics at the high school level. These workshops provided the teachers a means to obtain training in the use of minicomputers for classroom instruction and enabled the faculty to interact with members of the group. The 76 teachers were chosen from all areas of the state and contact with them proved to be most beneficial in the implementation of a high school recruitment program. For most of the teachers, the workshop provided their first exposure to a woman with a Ph.D. degree in engineering. Informal conversations on career counseling occurred spontaneously. These contacts within the school system provided a mechanism for interaction with regional high school students.

Teachers began to identify young women with high aptitides and refer them to the author. In one particular case, a local algebra teacher who had attended one of the workshops asked the author to help a talented black girl. The young girl's family income was quite low and she was under heavy pressure to quit school and help support her siblings. After many talks with the girl, she asked for help in obtaining financial assistance for attending college. She has recently started her internship in surgery at a regional hospital.

Conducting Women in Science Careers Workshops

The National Science Foundation has sponsored two Women in Science Careers Workshops at the University of Southern Mississippi, both directed by the authors. A third grant has been awarded for a workshop this winter. These workshops serve as a vehicle to provide career information and expose young women to successful women scientists. The advertising campaigns associated with the conducting of these workshops allows the directors to reach a segment of the population inaccessible to conventional career counselors. Those older women who are either unemployed or underemployed have difficulty in obtaining any counseling. Mass media advertising has proved to be an effective method of getting these women to attend the Women in Science Careers Workshops.

Intensive exposure of young women and older, reentry women to role models appears to be quite successful in encouraging them to choose a career in science. It is the authors' belief that effective role models must be attractive, personable, and well-adjusted in a family situation. A role model must also be someone with whom a young woman can identify. Preferably, the role model should come from the same geographic region and have a similar socio-economic background.

Disseminating Career Information

As discussed previously, one effective method of reaching some members of the target group is by interpersonal communication through direct contact with teachers or other influential persons. However, the older women in the region can only be reached through the mass media. The authors have conducted several state-wide media campaigns. These campaigns included television talk show appearances, radio spots, and articles sent to daily and weekly newspapers. The number of radio spots actually used cannot be documented although many applicants for the workshops first heard about the workshop activities on the radio. Clipping services provided 42 published newspaper articles which advertised the second Women in Science Careers Workshop.

Through visits to high school classes, talks to local clubs and civic groups, participation in professional teacher organizations, and campaigns using the mass media, career information and counseling can be provided to most members of the target group. This phase of the projects appears to be crucial to the successful recruitment of women into science curricula.

RESEARCH FINDINGS

The data collected during several projects are presented below, along with a short discussion of some of the conclusions drawn from analysis of this data.

During the first two Women in Science Careers Workshops projects, data were collected on 270 regional women who were either already in science educational programs or who planned to enter science programs. The respondents were mostly 18 or 19 years of age (50 percent) with a mean age of 20.3 years. They were predominantly caucasian, with 23 percent being black. The mean American College Testing Program (ACT) composite score was 19, with a range from 8 to 30. The mean ACT science score was 22.

Over 74 percent of the respondents had no high school career education. Mathematics was the most frequent minor (20 percent) and less than 5 percent received any encouragement to enter a career in science from either parent. Statistical analysis of the data showed few significant relationships among the demographic variables. The respondents' career aspirations were not significantly related to their parents' occupation or level of education. There was a positive correlation between their ACT composite scores and their choice of a non-traditional career in science. There were no significant relationships among the demographic variables: (1) age, (2) expected years of employment, (3) desired family structure, (4) race, and (5) choice of a career in science. A control group of 115 college women who were in non-science educational tracks was used for comparison.

The sex-role classification of each of the participants in the Women in Science Careers Workshops was tested using the Bem Sex Role Inventory as the test instrument.[2] A pre-test and a post-test was given to the participants in the workshops and each participant was asked to rate herself on both a real and ideal basis. The Bem test was also administered to 115 non-participants and this set of data was used as a control group. Sex-role classification was assigned for each respondent according to Table I.

Table I. Sex-Role Classification From Test Scores

Classification	Masculine Score Compared to Median	Feminine Score Compared to Median
Androgynous	Above	Above
Masculine	Above	Below
Feminine	Below	Above
Undifferentiated	Below	Below

The hypotheses that the workshop participants would score significantly more androgynous on their ideal and real sex-role identities after their participation in the workshop than the control group were supported by statistical tests, using the analysis of covariance. The ideal sex-role identities of the workshop participants were shown to be significantly more androgynous than their real sex-role identities as measured by the post-test. Analysis of the data also indicated that the participants did not differ significantly in their sex-role identities from the control group prior to participation in the workshop.[3] These results are presented in Table II.

Table II. Bem Sex-Role Inventory Median Scores for the Workshop Participants and Control Group

Characteristics	Participants				Control Group	
	Pre-Test		Post-Test			
	Real	Ideal	Real	Ideal	Real	Ideal
Masculine	4.53	5.85	5.19	5.80	4.70	5.55
Feminine	5.02	5.23	4.96	5.34	5.19	5.44

CONCLUSIONS

No one approach will bring about sex parity in scientific careers. Any program for recruitment of women into the sciences should be multi-phased and implemented over a period of time. Those working in projects of this type should not be discouraged by initial low response, since tremendous change in the sex-ratio in scientific fields has occurred in the past three decades--when viewed in the context of the centuries which passed with almost no change.

Most young women have been conditioned to believe that a career woman loses her feminity and must sacrifice marriage and a family. This appears to be a major obstacle in their choice of science as a career. Once exposed to role models who have successfully combined careers and family life, many young women raise their own educational goals and feel more confident about seeking a career in which they can find financial security and interesting work. The "masculine" characteristics[2] which they have been associating with careers in science become more desirable; and they tend to become more androgynous in their own sex-role identities--especially in their ideal identities.

A most important factor in recruiting young women from high schools is the development of good relations with high school teachers. Most educational systems, especially on the secondary level, do not provide career education. High school counselors have little information about science careers and tend to guide students into fields about which they have personal knowledge. It has been the experience of the authors that teachers will serve as career counselors, if provided information which they feel comfortable in discussing. Family members usually do not encourage their female children to pursue academically strong educational tracks, even on the secondary level. Whether the family's negative attitude toward women obtaining education for careers in science is caused by ignorance of the opportunities or sex bias is not apparent.

Recruitment programs which are carefully planned can yield results. Although success should not be measured in numbers only, enrollment figures do provide one measure of success. Enrollment figures for the Department of Computer Science and Statistics at the University of Southern Mississippi are presented in Table III. As shown in Table III, the total student enrollment has grown rapidly during the last six years. Early estimates of the 1982 enrollment indicate that the enrollment may reach 1,000. It should be pointed out that, while the overall enrollment has risen, the percentage of women has increased from 11.4 percent to 40.0 percent of the total student enrollment. The percentage of women over 25 has climbed from 1.0 to 4.9. Blacks have been able to attend the university for less than 15 years and their participation in computer science has increased from 3.1 percent to 8.8 percent.

Table III. Students Majoring in Computer Science and Statistics at the University of Southern Mississippi

Year	Males	Females	Females* Over 25	Minority* Females	Total Enrollment
1974	171	22	2	6	193
1975	150	30	4	10	180
1976	155	46	6	9	201
1977	176	88	14	28	264
1978	208	120	13	40	328
1979	260	168	19	51	428
1980	400	267	33	59	667

*Figures in these columns are included in total figures for females.

The retention of women in science programs is necessary also; and this issue has not been addressed in this paper. However, efficient recruitment into these programs must be the primary focus, since retention problems do not arise until they have entered these programs. Sex-role bias is thought by many computer scientists not to be a major factor in this field. The reason most often given is that this is such a new field that it has never been sex-role stereotyped. Performance on a computer can be viewed as independent of sex, since there is no means to build a sex bias into a machine. Perhaps the future will eliminate the sex bias now existing in educational institutions and in industrial complexes--this, however, cannot occur until sex-role attitudes change in our societies.

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3. PROJECT SEISMIC

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Project SEISMIC is designed to encourage secondary school personnel to increase sex equity in the educational system and to promote practices free of sex bias within the community. Project components include a staff development program, curriculum methods and materials, and community outreach strategies. Teachers, counselors, and administrators can use these components in a comprehensive effort towards increasing equal treatment of the sexes in educational and vocational settings.

Project SEISMIC contains a broad array of materials for use by teachers, students and employers. Materials include video tapes, student worksheets, lesson plans and guides to conducting workshops. The materials have been tested and refined in many school settings and are now in use throughout New York State.

The ultimate goal of Project SEISMIC is to open up career options for females (as well as males) beyond those dictated by tradition. In order to do so three groups need to be educated: the faculty, the students and the employers. Thus Project SEISMIC provides interactive educational experiences targeted for each group. Todays presentation will provide the rationale and a sample of the materials and activities for two of these groups: the teachers, and the students.

Staff Development: Educators need to participate in sex-equity workshops because their training has contributed to their sex-stereotyped beliefs (Harris and Smith, 1976 and McCune, 1977). Counselor education has not been any better than teacher education in reducing sex-bias. Verheyden-Hillard writes that the research literature indicates that counselor preparation and practice are perceived to be sexist and discriminatory. Nevertheless, few counselors or teachers of either sex would describe themselves as sexist. Thus, the sex-bias in their interaction with students is often subtle and frequently unrecognized by both counselor (or teacher) and students.

Pietrofessa and Schlossberg (1971) tape recorded interviews of counselors with a female student who expressed indecision about whether to enter engineering or the field of education. Results indicate that both male and female counselors displayed disapproval toward the female students entering the "masculine" field. Counselors suggested to their students that engineering "is a man's field," "takes longer than education to train for," "lower status," "requires working after 3:00 p.m.," "is unpeopled" etc. The authors indicate that such statements influence female students toward tradition-bound stereotyped options.

The findings of Thomas and Stewart (1971) suggest that students who are ambivalent regarding a non-traditional career may find counseling more of a hindrance than a help. Counselors rated traditional goals more "appropriate"; were more accepting of students with traditional goals; and considered students with non-traditional goals to be in need of counseling.

At a recent meeting of the American Educational Research Association (April 1980) the Sadkers provided additional evidence demonstrating that teachers receive virtually no exposure to sex-equity issues during their years of training. Less than 1% of the content of the most popular textbooks in teacher education (all subject areas) deal with sex-equity. Project SEISMIC compensates for this ommission in teacher training.

In that it is socially undesirable to manifest sexist attitudes and behaviors, school personnel are not likely to accept, confront, and deal with their own sex-biases. The first component of Project SEISMIC was designed to help counselors and teachers become more aware of their own attitudes in this area.

A series of activities are designed to familiarize faculty with the social and legal impact of sex-inequities. Workshops focus on increasing teachers self-awareness of the attitudes they hold towards expanding sex-roles and the effect of these attitudes on the teaching and counseling process.

Each of the activities require that small leaderless groups of teachers work together in analyzing their own views which are then compared to research findings. The activities which are highly structured, are guided by both videotape and print material. These materials allow any small group to run a sex-equity workshop without requiring the leadership of a trained expert.-

The workshops assist participants in clarifying their own attitudes concerning sex role expectations and to sensitize them to subtle revelations of sex role stereotyping in faculty/student interactions. Participants engage in the following activities:

- Examine sex differences in occupational choices.
- Examine their own views of the roles of men and women on the job and in the home.
- Examine their own views of working women.
- Evaluate the effect of faculty responses on students' career choices.

The aim of the first three activities is to provide an environment for reflection and shared experiences with regard to expanded sex roles. The last activity focuses on the effect of faculty/student interactions on students' career exploration in a rapidly changing world.

/Excerpts from the videotape "Issues in Sex-Equity" will be shown to the audience. If sufficient time is scheduled, then the audience will have the opportunity to participate in one or two of the activities. The guide for these activities is enclosed/.

Classroom Curriculum

The effort to wipe out sex inequity in the schools has often overlooked the most sex-stereotyped participant in the educational system - the student.

The Project SEISMIC Curriculum guide is for those educators who wish to introduce their students to a broader perspective concerning the roles of males and females in our society. Teachers and other educators can be influential in exposing their students to a wider range of options than those espoused by tradition. In many communities teachers are among the most educated and outspoken citizens. They are, in fact, role models for generations of young people. Through their considerable influence, educators can guide their students beyond a mere acceptance of the status quo.

Stereotypes about men and women still abound in our society. Although many young people no longer accept blatant myths about the inadequacy of women for certain jobs and careers, neither they, nor anyone else living in American society, are immune from the more subtle forms of stereotyping: students may admit that a woman can be a mechanic, but they suggest that she wouldn't enjoy it. There are unasked questions when a male chooses to be a nurse, questions that are seldom contemplated when a female makes the identical choice.

For those students who continue to support traditional roles, there is often a cost in the loss of human dignity and self-esteem. Research demonstrates the negative results for both males and females of continued sex-stereotyped thinking:

- By the time they reach the upper elementary grades, girls' visions of future occupations are essentially limited to four: teacher, nurse, secretary or mother. Boys of the same age do not view their future occupational potential as so limited. (O'Hara, 1962)[1]
- Although women make better high school grades than do men, they are less likely to believe that they have the ability to do college work. (Cross, 1978)[2]

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1. Robert O'Hara, "The Roots of Careers," Elementary School Journal, 62, no. 5 (Feb. 1962): 277-280.
2. Patricia Cross, "College Women: A research Description," Journal of National Association of Women Deans and Counselors, 32, (Autumn 1978): 12:21.

- Decline in career commitment has been found in girls of high school age. This decline was related to their feelings that male classmates disapproved of a women's using her intellignece. (Hawley, 1971)[3]
- Of the brightest high school graduates who do not go to college, 75-90% are women. (WEAL)[4]

By having chosen teaching as a career, most educators have made a commitment to introduce students to new skills and ideas. The Project SEISMIC curriculum guide is for those educators who would like to introduce their students to the idea that career aspirations need not be limited by stereotypes but can be a true reflection of the individual's skills.

The Project SEISMIC: Curriculum guide, used in conjuction with videotapes and classroom materials, forms the basis for a comprehensive sex equity unit for use with secondary school students.

Materials

I. Curriculum guide. This guide includes all print materials necessary for faculty preparation of classroom lessons.
    A) Introductory material
    B) Six fully developed lessons
    C) One copy of all materials to be duplicated for classroom use
    D) Videoscripts/videotape synopses
    E) Concise references providing background on sex equity issues.

II. Videotapes* (3/4" color cassettes)
    A) Person to Person: Choices in a Changing World - Stimulus "dilemmas" designed to focus attention on sex equity issues to be "solved" by students.
    B) New on the Job - A 15-minute documentary videotape featuring two women and one man who have made non-traditional career choices.

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[3] Peggy Hawley, "What Women Think Men Think," Journal of Counseling Psychology, 18, no. 3 (Autumn 1971): 193-194.

[4] Facts About Women in Education, prepared by the Women's Equity Action League. Can be obtained from WEAL, 1253 4th St., SW; Washington, DC.

/The presentation will include a description of two lessons. One of these focuses on choosing non-traditional careers and the other helps students to provide peer support for those individuals who have made non-traditional career choices. Excerpts from the videotapes, which are components of these lessons, will be shown. The overview (or summary) of the two lessons is enclosed. Also included is a description of the videotapes for each lesson./

staff development
curriculum
community outreach

project SEISMIC
sex equity in schools/modules in careers

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Center for Advanced Study in Education
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University of the State of New York

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The goal of Module A is to assist you in examining and clarifying the attitudes you hold about sex equity issues which may affect your interactions with students. Module A is also concerned with exploring ways in which to handle faculty-student interactions so that they are free of sex bias.

The activities which comprise this module are directed by both this workbook and the videotape: *Issues in Sex Equity*. In each of the activities there are a series of tasks. Some of the tasks ask you to work independently by reading or by filling out a worksheet; others ask you to share your views in your small groups.

The module is designed to be leaderless, i.e., you will be able to follow directions without the intervention of a leader. The Facilitator functions only to operate the videotape machine and to remind the group of the time constraints.

You are now ready to begin Module A.

Go to next page.

Task 1.1

Facilitator:	**Use the videotape: *Issues in Sex Equity*. Set Memory counter at #000 and turn on videotape.**
Participants:	**View videotape.**
Facilitator:	**When directed by narrator, turn off videotape.**
	Go to next page.

Task 1.2

Participants: **Read this page.**

Facilitator: **Allow up to 2 minutes.**

Rationale for Activity

Everyone has personal views on the roles of the sexes. These views influence our life styles, our attitudes towards ourselves and others, and our actions.

Many people believe that particular attributes or characteristics of the sexes are biologically or genetically determined, when frequently they are the result of subtle, yet pervasive conditioning starting at infancy. Such beliefs obviously play a significant role in the way educators counsel students, even though all professionals would agree that personal values should not influence such counseling.

Biological and physical differences do exist between the sexes. It is important to acknowledge these differences, but they should be separated from those which are *culturally determined.* Career exploration and counseling should be based on an individual student's characteristics, interests and abilities, as well as on the requirements for success in the career he or she is considering.

We are in a time of transition when our society is struggling to shake off long established, deeply rooted, yet subtle biases. Educators, therefore, have special responsibilities to achieve greater awareness of their personal attitudes and beliefs.

Achieving greater self-awareness requires that you, as an educator:

1. Examine your personal views from time to time.
2. Examine *why* you believe what you believe and to what extent this is based on evidence.
3. Determine what actions you can take so that your attitudes and beliefs will not get in the way of your responsibility to work objectively with students in a rapidly changing world.

To help you with these steps, this workshop will focus on increasing self-awareness. If you approach these activities openly, you can gain a great deal from them. If, on the other hand, you try to anticipate the outcome of these activities by taking the view that there are no differences between the two sexes at all, or by indicating only the most "socially acceptable" responses, these activities will have less value for you and for other members of your group.

Participants: Wait for Facilitator signal to proceed.

Facilitator: After no more than 2 minutes, move on to next task.

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Task 1.3

Participants: On the next page you will find a worksheet listing selected occupations. For each occupation, do the following without consulting with your group:

Column I	- Enter your own estimate of the percentage of workers that are female in *today's* labor force.
Column II	- Enter your own estimate of the percentage of the labor force that would be female in a *future society* that would have *no sex bias.*
Column III	- For any occupation that you feel would *not* have approximately equal representation of male and female workers in the future, indicate the reasons you feel the imbalance would still occur.

Go to next page.

Facilitator: **Allow up to 15 minutes.**

Worksheet: Task 1.3
Percentage of Females in Selected Occupations

OCCUPATION	FEMALE REPRESENTATION		
	PRESENTLY	IN THE FUTURE	
	I PERCENTAGE	II PERCENTAGE*	III REASON
1. Engineer			
2. Nursery School Teacher			
3. Practical Nurse			
4. Keypunch Operator			
5. Bus Driver (Public, School)			
6. Construction Worker			
7. Office Receptionist			
8. Automobile Mechanic			
9. House Worker (Private household cleaner, servant)			
10. Firefighter			
11. Machinist			
12. Building Maintenance (Janitor, Sexton)			
13. Shipping, Receiving Clerk			
14. Plumber, Pipefitter			
15. Electrician			
16. Hairdresser, Cosmetologist			
17. Secretary			
18. Bank Teller			
19. Lawyer			

*If future percentage is not at or close to 50%, give reason for imbalance.

Participants: Wait for Facilitator signal to proceed.

Facilitator: After no more than 15 minutes, move on to next task.

Task 1.4

Facilitator: **Turn on videotape to *Activity 1: Feedback: Occupational Statistics on Employment of Women.** Memory counter at about #135.**

Participants: **View videotape and compare your worksheet, Column 1, estimates with those reported.**

Facilitator: **Turn off videotape as directed by narrator.**

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*A copy of these statistics can be found in the Appendix.

Task 1.5

Participants: **Arrive at a group consensus on the reasons the occupations listed below presently have a very low representation of female workers. Space for notes is provided.**

Facilitator: **Allow up to 10 minutes.**

Worksheet: Task 1.5
Occupations with Low Female Representation in 1980

OCCUPATION	PERCENTAGE OF FEMALES	REASONS FOR UNDER-REPRESENTATION
1. Construction Worker	2.7%	
2. Firefighter	0.4%	
3. Automobile Mechanic	0.6%	
4. Plumber	0.7%	
5. Electrician	1.3%	
6. Engineer	2.9%	

Participants: **Wait for Facilitator signal to proceed.**

Facilitator: **After no more than 10 minutes, move on to next task.**

Task 1.6

Participants: **As a group, select 2-3 occupations from your *Worksheet: Task 1.3, Column III,* that you feel will be less than 30% *female* in a future where there is no sex bias. Arrive at a group consensus on the reasons for this imbalance. Space for notes is provided below.**

Facilitator: **Allow up to 5 minutes.**

Worksheet: Task 1.6
Occupations with Few Females in the Future

OCCUPATION	REASONS
1.	
2.	
3.	

Participants: **Wait for Facilitator signal to proceed.**

Facilitator: **After no more than 5 minutes, move on to next task.**

Task 2.1

Facilitator: **Turn on videotape to *Activity 2: Roles, Introduction.* Memory counter at about #215.**

Participants: **View videotape.**

Facilitator: **Turn off videotape as directed by narrator.**

Task 2.2

Participants: **On the next page, you will find a worksheet containing statements about the various roles of women. Without consulting with your group, review each statement on the worksheet, indicate the strength of your *personal* agreement or disagreement, and circle the appropriate number. You will have an opportunity to discuss these statements with other members of your group during a subsequent task.**

Go to next page.

Facilitator: **Allow up to 5 minutes.**

Worksheet: Task 2.2
Role Expectations for Women—Personal Beliefs

ROLE EXPECTATIONS	PERSONAL BELIEFS				
	STRONGLY AGREE				STRONGLY DISAGREE
1. Although women may say that they want careers, their primary interest is to become wives and mothers.	1	2	3	4	5
2. Although women can be socialized to be competitive in the business world, this is contrary to their tendency to be gentle and nurturing.	1	2	3	4	5
3. Since most women are subject to mood swings and can become emotional and excitable at least part of the month, they should not hold positions that require stable judgment.	1	2	3	4	5
4. Due to the fact that women do not do as well as men in scientific subjects, it would be a disservice to encourage them to pursue careers in this [illegible]	1	2	3	4	5
5. Assertive women alienate their co-workers, bosses, and teachers. Therefore, it is important for counselors not to provide encouragement for out-spoken behavior in female students.	1	2	3	4	5
6. In the long run, since men are heads of households, women who work are taking income away from families.	1	2	3	4	5
7. While one may legislate sex equity principles, the actual practices lag so far behind the rulings that it would be a disservice to encourage women to train for non-traditional careers.	1	2	3	4	5
8. A working wife will become too independent.	1	2	3	4	5
9. A married man's chief responsiblity should be to his job.	1	2	3	4	5
10. Pre-school children suffer if their mothers work.	1	2	3	4	5
11. If a woman is not satisfied being a wife and mother, it is a sign she has emotional difficulties.	1	2	3	4	5

Participants: **Wait for Facilitator signal to proceed.**

Facilitator: **After no more than 5 minutes, move on to next task.**

Task 2.3

Participants: Now that you have considered your personal beliefs concerning role expectations of women, consult with your group as follows:

1. Use the copy of *Role Expectations for Women: Group Consensus* on the next page *(Worksheet: Task 2.3).*
2. Discuss each statement on the list.
3. To the extent possible, try to come to consensus on how your group feels about the statement.
4. Circle the number that most closely reflects your *group's* decision about each statement.

Go to next page.

Facilitator: **Allow up to 15 minutes.**

Worksheet: Task 2.3
Role Expectations for Women—Group Consensus

ROLE EXPECTATIONS	GROUP CONSENSUS				
	STRONGLY AGREE				STRONGLY DISAGREE
1. Although women may say that they want careers, their primary interest is to become wives and mothers.	1	2	3	4	5
2. Although women can be socialized to be competitive in the business world, this is contrary to their tendency to be gentle and nurturing.	1	2	3	4	5
3. Since most women are subject to mood swings and can become emotional and excitable at least part of the month, they should not hold positions that require stable judgment.	1	2	3	4	5
4. Due to the fact that women do not do as well as men in scientific subjects, it would be a disservice to encourage them to pursue careers in this area.	1	2	3	4	5
5. Assertive women alienate their co-workers, bosses, and teachers. Therefore, it is important for counselors not to provide encouragement for out-spoken behavior in female students.	1	2	3	4	5
6. In the long run, since men are heads of households, women who work are taking income away from families.	1	2	3	4	5
7. While one may legislate sex equity principles, the actual practices lag so far behind the rulings that it would be a disservice to encourage women to train for non-traditional careers.	1	2	3	4	5
8. A working wife will become too independent.	1	2	3	4	5
9. A married man's chief responsiblity should be to his job.	1	2	3	4	5
10. Pre-school children suffer if their mothers work.	1	2	3	4	5
11. If a woman is not satisfied being a wife and mother, it is a sign she has emotional difficulties.	1	2	3	4	5

Participants: Wait for Facilitator signal to proceed.

Facilitator: After no more than 15 minutes, move on to next task.

Task 2.4

Facilitator: Turn on videotape to *Activity 2: Roles, Commentary on Issues*. Memory counter at about #225.

Participants: View videotape.

Facilitator: Turn off videotape at end of *Activity 2: Roles*.

Task 2.5

Participants: You have now completed Activity 2. As a group, decide on when to continue with Activity 3, which runs for about 30 minutes.

Go to next page.

Task 4.1

Facilitator: Turn on videotape to ***Activity 4: Faculty-Student Interactions: Introduction.*** Memory counter at about #375.

Participants: View videotape.

Facilitator: Turn off videotape as directed by narrator.

Task 4.2

Participants: Identify all the verbal and non-verbal cues in the faculty member's first response that could discourage Mary's interest in Electrical Trades.

Facilitator: Allow up to 2 minutes for discussion; then move on to the next task.

Task 4.3

Facilitator: Turn on videotape: *Activity 4: Feedback for Response #1; Response #2.* Memory counter at about #405.

Participants: View videotape.

Facilitator: Turn off videotape as directed by narrator.

Task 4.4

Participants: Identify all the verbal and non-verbal cues in the faculty member's second response that could discourage Mary's interest in Electrical Trades.

Facilitator: Allow up to 2 minutes for discussion; then move on to the next task.

Task 4.5

Facilitator: Turn on videotape: *Activity 4: Feedback for Response #2: Response #3.* Memory counter at about #425.

Participants: View videotape.

Facilitator: Turn off videotape as directed by narrator.

Task 4.6

Participants: Identify all the verbal and non-verbal cues in the faculty member's third response that could discourage Mary's interest in Electrical Trades.

Facilitator: Allow up to 2 minutes for discussion; then move on to the next task.

Task 4.7

Facilitator: Turn on videotape: *Activity 4: Feedback for Response #3.* Memory counter at about #450.

Participants: View videotape.

Facilitator: Turn off videotape as directed by narrator.

Task 4.8

Participants: Read this paragraph.

As you have seen in the videotape segment, negative and discouraging messages can be sent to students through non-verbal cues. Although the actual words used may be neutral and provide accurate information, the faculty member still must be on guard not to convey negative feelings through tone of voice and body language. The following tasks are designed to help you further evaluate faculty interactions with students.

Go to next page.

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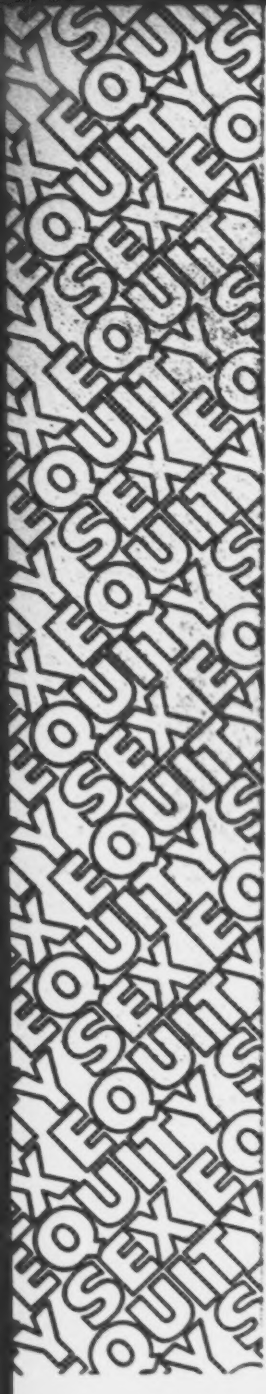

staff development
curriculum
community outreach

project SEISMIC
sex equity in schools/modules in careers

Deanna Chitayat
Anita Baskind
Robert Miller
Harvey Lieberman

Institute for Research and Development
in Occupational Education
Center for Advanced Study in Education
The Graduate School and University Center
of the City University of New York

In cooperation with the
OFFICE OF OCCUPATIONAL AND CONTINUING EDUCATION,
Special Programs
The New York State Education Department
University of the State of New York

CASE 04-81
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Lesson Overview 3: Non-Traditional Careers

Theme	Sex stereotyping in job choice is challenged through a two-step procedure. First, student stereotypes are revealed and then they are shown to be invalid. This is accomplished through discussion questions, a written exercise, and a 15-minute videotape depicting people in non-traditional careers. Finally, students are encouraged to expand their own career choices.
Concept Development	Six successive concepts are taught, each one building on the preceding one. Concept development proceeds as follows:
Concept 1:	**Many factors affect your choice of job.**
Concept 2:	**Other people subtly influence your choice of job.**
Concept 3:	**We have expectations about which jobs are suitable for males and females.**
Concept 4:	**Sex stereotyped expectations about job capabilities are not always valid.**
Concept 5:	**Some people have found non-traditional jobs very rewarding.**
Concept 6:	**You can expand your work options beyond traditional choices.**
Procedure	In the lesson plan on the following pages each activity segment builds toward a particular concept. In order to provide closure, the teacher should emphasize or highlight the concept at the end of each segment. The lesson plan is highly structured to develop the concepts. However, it also allows for a flexibility of uses and creative expansion by the teacher.
Materials	Student Worksheet: Who Does This Kind of Work? (see page 23) Videotape: *New on the Job* (15 minutes) Videotape Synopsis: (see page 24)
Teacher Preparation	Read lesson plan Review worksheet: Who Does This Kind of Work? (see page 23) Preview videotape: New on the Job (15 minutes) Read Sex Equity References: Historical Perspectives of Sex Role Expectations: 1930-80 Sex Stereotyped Occupations in the Labor Force Secondary Level Sex Stereotyped Occupational Education Courses Sex Equity in the Workplace: It's the Law!

Videotape Synopsis—New on the Job (15 minutes)

This documentary presents live videotaped interviews with three people working in a non-traditional setting for their sex. A narrator sets the scene by referring to the changing work world.

Jackie Simmons is an electrician apprentice working at an apartment building construction site. She enjoys seeing the product of her work—all the apartments lit up—and knowing she helped make it happen. She sees the men on the job as individuals; some accept her and others are more traditional in their ideas: "It would even be hard to bring them into the space age!" Her supervisors feel she is doing her share of the work; if she needs help, she'll ask for it. They are proud that their union has opened the field to women before the government laws forced them to do it.

Mary Jane Squires is a customer engineer for IBM. She services typewriters for clients by operating the machine, diagnosing the problem and fixing the machine, using her fingers and hand tools. She is aware of the problem of some women using their "femininity" to get special treatment or to explain difficulties. However, her attitude is that "all of us will face a situation in which we don't know how to fix one of the machines—that's a customer engineer problem, not a *female* customer engineer problem." She also speaks of the pressure to do well when you are the "only one of your kind" at a meeting. Her supervisor speaks of the need to keep expectations the same for all workers. He also points out the opportunities for women, and men, in this growing field.

Luis Serrano is a day care worker in a center for 3- and 4-year-olds. He is seen leading the children in song and helping them at a "milk" break. He speaks of serving as a male role model for the children of women without husbands and of showing through his activities that males do not lose their manhood by caring for young children. His supervisor points out that there have been no complaints from parents about a male working with young children. He mentions the common traits of all people who work with children: caring about children and deriving a sense of self-esteem from working with them.

Lesson Overview 4: Peer Support for Non-Traditional Choices

Theme

A stimulus videotape helps students develop peer support for individuals making independent, non-traditional choices in courses and careers. Acting according to one's own abilities and needs is supported as being a source of satisfaction.

Concept Development

Four successive concepts are taught, each one building on the preceding one. Concept development proceeds as follows:

Concept 1: **Choosing to do something different from your peers may arouse feelings of conflict.**

Concept 2: **Not acting on the basis of your own interests can cause feelings of dissatisfaction.**

Concept 3: **Supporting peers who make non-traditional choices is encouraging independence.**

Concept 4: **Supporting non-traditional choices now will make it easier in the future for males and females to choose careers and courses based on ability and interest.**

Procedure

In the lesson plan on the following pages each activity segment builds toward a particular concept. In order to provide closure, the teacher should emphasize or highlight the concept at the end of each segment.

The lesson plan is highly structured to develop the concepts. However, it also allows for a flexibility of uses and creative expansion by the teacher.

Materials

Student Worksheet: What Should They Do? (see page 29)

Videotape: *Person to Person: Choices in a Changing World*
Section 1, Mary; John (3 minutes)

Videoscript (see page 30)

Teacher Preparation

Read lesson plan

Review worksheet: What Should They Do? (see page 29)

Preview videotape: *Person to Person: Choices in a Changing World*
Section 1, Mary; John (3 minutes)

Read Sex Equity References:
Historical Perspectives of Sex Role Expectations: 1930-80
Women of Importance in Fields Perceived to be Male Domains

Videotape/Videoscript—Person to Person: Choices in a Changing World. Section 1: Mary; John

Mary

Well I've been thinking about my future a lot. I'm in a secretarial program at Manning Vocational and I really hate it. I like working with my hands but don't like being in an office all day. I was thinking—my dad is an electrician and I've gone on jobs with him and my brother. I really like the work and my dad thinks I'm good at it. I know this might surprise you—but I'm thinking of switching over to the Electrical Trades program. Now my counselor didn't seem to think the idea was so hot. He said I'd be the only girl in Electrical Trades, and that once I got out I might have a hard time finding a job. But, still, I like electricity, and so I'm not sure what to do.

John

I'm at William S. Morrison High School. Last semester, everybody had to take sample courses in wood shop, sewing, metal work, and cooking. In the sewing section, Mrs. MacElroy—that's our teacher—said that last year in the elective sewing class a couple of students made down vests for themselves.

Well, I've been wanting to get a down vest since last winter, but my parents say they don't have the money now. And I think that I would make a down vest if I took elective sewing. But...here's the problem. Boys don't usually sign up for sewing. I'd be the only boy in an all girl class. I don't mind that so much but I wouldn't go for it too much if everybody laughed at me. Well, that's my problem: do you think I should take elective sewing or not?

4. LOUGHBOROUGH UNIVERSITY WOMEN IN ENGINEERING PROJECT

G.E. Chivers, Centre for Extension Studies
Loughborough University of Technology, UK

Introduction

The work described in this paper stems originally from my concern about the very low proportion of girls and women studying physical sciences and engineering in the United Kingdom with a view to careers in technological fields. The U.K. has about the lowest proportion of women professional engineers of any country in the developed world. Undoubtedly the situation is particularly poor because the British place engineering in rather low esteem, and completely misunderstand the role of professional engineers in society.

While some of the work described here is concerned with influencing older girls (over sixteen years) taking science subjects to consider careers in engineering, interest has also developed in the reasons why younger girls (twelve to sixteen years) drop the study of physical science subjects (especially physics). This interest arises because few girls in Britain continue with the study of physical sciences beyond the age of fourteen or fifteen. Once they decide to drop such studies it then becomes very difficult for them to go into any kind of technological career at a later stage. This falling away of interest in physical sciences is illustrated by the fact that girls constitute 28 per cent of ordinary level physics candidates, 18 per cent of advanced level physics candidates and 12 per cent of undergraduate physics students. Part of the reason for the very low proportion of girls who achieve the necessary qualifications in physical sciences and maths at school is the lack of effective careers advice for girls.

We have formed a small research and development team at Loughborough University to investigate all these problems and to develop programmes to overcome them.

Initial Research

A study of the career development of 345 women engineers in 1974-76 showed that they had received very little encouragement at school to take up careers in engineering. Only two per cent felt that their schools had been most influential in encouraging them towards such careers. Friends and family were a much more important influence, indeed many had fathers or close relations who were engineers. Thus, this research which was mainly concerned with later career development indicated that an important part of the overall problem lay with schools.

A further piece of evidence in 1976 was the response from schools towards a pilot scheme developed by the Engineering Industry Training Board to encourage more girls into industry as technician engineers. This scheme involved payments to girls (and subsequently to their employers) who would take up training places to train as technicians. Although employers were willing to develop the scheme, many head teachers in schools were initially hostile to the idea. One head teacher described the thought of girls from his school training to become technicians in engineering as ridiculous. This was despite the fact that many boys from the same schools were training as engineering technicians.

It was clear from this reaction that many schools were either failing to give girls any information or advice about careers in technology and engineering, or were actually discouraging them from considering careers in these fields. In the end the EITB was able to contact enough girls interested in becoming technician engineers (often through women's magazines) to get the scheme started. So far this scheme has proved successful and the EITB became interested in the possibility of an initiative to encourage more girls into engineering at the professional level.

In 1978, Mr. Eric Lake of the EITB was given special responsibility for new initiatives in this field. He visited me at Loughborough University because of my research activities on women in engineering and we discussed possible developments. At this time I had become aware of developments in the USA concerning women in engineering. The American universities and engineering institutions had been working hard during the 1970's to increase the proportion of women going into engineering. I therefore visited the USA in the Spring of 1979 to investigate the initiatives which were being taken, and to find out which ones were proving most successful. This visit showed that perhaps the most useful way in which universities could encourage girls to consider careers in engineering was by holding residential courses for interested girls during the Summer.

We therefore decided to hold a one week 'pilot' course at Loughborough University in July 1979. This would be for girls aged seventeen who were taking maths and physical science subjects at school or college and who wanted to know more about professional engineering as a career. The costs of the course would be covered by the EITB and girls would be selected on the basis of academic ability, interest in learning about engineering careers, and evidence of wider interests and suitable personalities. A national publicity campaign was carried out and over 600 applications were received for 30 places on the course. This was far in excess of our expectations and the number of places was in fact increased to 45. Even so many applicants had to be disappointed.

The 45 girls were split into five groups of 9 girls and each group was placed under the direction of a group leader. The group leaders were all women engineers in their mid-twenties with degrees and further professional qualifications working in industry. They were released for the week by their employers who paid the women engineers as normal in the belief that the programme was very worthwhile. These group leaders spent the whole week with their girls and acted as advisers and role models.

The residential course consisted or talks about various areas of engineering, visits to relevant University departments, talks by older women engineers about their careers, advice about degree courses, and most importantly a full day in industry. The day in industry consisted of small groups of girls (usually three in a group) visiting a range of manufacturing and consultancy companies in the vicinity of the University. The whole day was spent with professional engineers of the company discussing their work and showing the girls what they did in their normal work.

At the end of the week the girls had a very much better idea of what engineering was about at professional level. They were in a position to decide whether a career in engineering appealed to them or not. If it did interest them they could begin to decide which branch of engineering they wanted to study, and which degree courses to apply for.

Follow-up studies of the outcome of the course were twofold. A questionnaire on the course itself showed that the girls found the day in industry to be of particular value, closely followed by visits to University engineering departments. However, all aspects of the course programme had been considered very worthwhile and our confidence was rising that some of the girls might indeed be considering engineering careers. The role played by the group leaders was particularly important and most girls commented very favourably on the help and advice given by them. We asked all the girls who attended the course to let us know later in the Autumn about their career decisions. We finally received information on the decisions reached by 41 of them. Of these 41 girls, 37 decided to take a degree course in engineering or engineering science, with the remainder deciding to take degree courses in maths or physics.

In view of the great success of the course in encouraging girls to take up careers in engineering, the EITB decided to arrange for nine universities spread around the U.K. to offer similar courses in 1980, while ten universities offered courses in 1981. Loughborough University has been involved for all three years and we have continued to take 45 girls each year. Over 400 girls are now placed on these one week courses (described as 'Insight' courses) and applications for places in 1981 numbered over 3,000. An important feature of the 'Insight' courses has undoubtedly been the fact that they are restricted to girls. While this may seem unfair to boys, it has resulted in the courses having much more impact with the media. Indeed, it could be argued that the publicity impact of the 'Insight' programme has been at least as important as the outcome of the courses themselves. Another important consideration is that the majority of girls on the first 'Insight' course stated that they would not have applied to attend if the course had been open to boys as well as girls. This reluctance of girls to compete with boys in science and technology is a continuing problem from a young age, and does argue for some sex segregation in teaching and a good measure of positive discrimination in training. Another important spin-off from 'Insight' courses is the likelihood that the girls involved will go back to their schools full of enthusiasm for technological careers.and armed with valuable information of benefit to other school pupils (and also teachers).

Important general conclusions from the 'Insight' programme are that girls are very lacking in information about technological careers and industry, that they benefit greatly from direct contact with engineers and technologists in a working situation, and that young women engineers are of great importance as role models for these girls.

Research Studies with Insight Applicants and Women Engineering Students at Loughborough University

The Survey Sample

The 'Insight' programme applicants provided a pool of girls from whom we could select a cross-section for interview. We were particularly concerned to obtain information on what had attracted them towards engineering as a possible career. Also of interest were the attitude of parents and teachers, and the sources of careers advice which had been available to the girls. One difficulty was finding the resources to interview applicants because they came from all over Britain and a good deal of travelling was involved. Finally, 29 girls were interviewed (alone) at their homes or at school using a very detailed and structured questionnaire. A wealth of valuable information was obtained, and even with a sample of this size we have a good deal of confidence in the significance of the results obtained.

However, while this work was in progress a parallel development was taking place which proved of great value to our research and development programmes. I had found in the USA that at a number of universities which had achieved success in recruiting women engineering students, campus based student societies for women engineering students had been formed. These societies were affiliated to the national Society of Women Engineers (SWE) and were very active in recruitment and careers advisory work on behalf of the universities concerned. The student members found considerable benefit in joining a society of women engineering students from all branches of engineering who could support and assist each other. We therefore decided to work with interested students to form a women's engineering student society at Loughborough University. In order to do this we had to contact women engineering students across the University, and obtained for the first time a listing of all such students. We were pleased to find that the University had well over 100 women students in engineering departments, and from these a sufficient number have been interested in joining the new women's engineering society. These students have been a very useful source of support and role models for a programme of school visits and continuing liaison which is described below. They were also another pool of girls that we could interview. We therefore decided to interview some of the students (on a voluntary basis) to provide further information on developments during their school days. We also used the opportunity to obtain some information on their experiences of university life as women engineering students. Very similar results were obtained from each group concerning experiences and problems at school, so that we were able to pool the results to obtain a total sample size of 55 for key questions.

Subject Choices at School

The background of the girls interviewed in terms of their home area, social class, type of school attended, occupation of parents and related factors will all have some bearing on the responses to particular questions. However, in this paper we are not reporting the differences and correlations based on these criteria. Rather we are reporting the many clear similarities in the problems faced by the girls as a result of their deciding to look into or indeed follow very atypical careers for women.

Investigations of ordinary level and advanced level subjects taken at school (or college) by the girls interviewed, their reasons for taking them, problems over choosing between subject options and related issues have revealed considerable variation in practice from school to school. The secondary education system in the United Kingdom is decentralised, with head teachers having a great deal of control over the bias of subjects taught. The results obtained from our study were therefore rather complex. However, broad agreement was reached with other research concerning the key issues, particularly the very young age at which girls have to decide whether or not to continue studying science subjects, and the ease with which they are allowed to opt out of physical sciences. At no schools were girls required to take physics beyond the age of fourteen, and in some schools girls could drop all science subjects (even the biology option) at this stage.

In some schools the option choices were arranged so that girls had to choose between physics and 'arts' subjects such as history or a second foreign language, subjects which are certain to be popular with girls. In many schools practical subjects which might attract girls towards engineering, such as metal work or technical drawing were seen as alternatives to science for the less academically able, and were likely to be offered as option subjects against physics or chemistry. In any case, single sex girls schools did not always have facilities for such subjects, and in mixed schools there was still a strong tendency to organise the study of practical subjects on sexist lines, with boys taking technical drawing or wood/metal work, while girls took domestic science or home economics.

Questions on the relationship between subject choices at thirteen and decisions about a career in engineering were extremely revealing. Thus, of the total group of 55 in the survey, fully 29 of the girls decided on a career in engineering only after choosing their advanced level subjects. A mere 5 of the girls had decided on a career in engineering before choosing their ordinary level subjects. Hence, only these five girls were influenced in their choice of ordinary level subjects by the idea of a career in engineering, while 29 girls made their choices of subjects to study at thirteen and sixteen without any thought of engineering as a career. It is not surprising that girls of thirteen have not given much consideration to possible careers, and this result should be taken in conjunction with later results on lack of effective careers advice at school for the girls in the study.

Careers Advice While at School

The survey showed that while 45 of the girls had talked to a careers teacher, only one of the teachers concerned was dealing with careers advisory work on a full-time basis. In addition, only 20 per cent of the part-time careers teachers to whom the girls spoke were science teachers. Thus, most of the formal careers advice given to the girls at school came from teachers of arts subjects, with only a part-time involvement with careers. Some very critical comments were made by girls interviewed about the lack of useful advice given by these teachers to girls expressing an interest in careers in engineering or applied science.

Many of the girls had turned to their teachers of physics, chemistry and mathematics for advice on careers. Unfortunately, even these teachers often had very limited knowledge about careers in technology. We obtained clear evidence of some teachers trying to put girls off careers in engineering in favour of careers in pure science. This is despite the much better career opportunities for engineers in the U.K. Those few teachers who were enthusiastic about careers in engineering had invariably worked in industry before entering the teaching profession.

Over half of the girls had seen a local authority careers adviser to discuss their ideas about careers in technology.While some of the girls found the careers adviser helpful, others were again critical, either of their lack of knowledge about engineering careers, or the amount of time available for the interview.

Most of the girls had discussed their career ideas with their families and friends. A significant proportion of the group had fathers or close relatives in engineering, and this had undoubtedly been an influence for some girls in deciding on a career in engineering. Amongst other possible sources of information about engineering careers, leaflets and brochures were most frequently cited as being an influence. However, careers conventions, television and radio programmes, books, newspapers and magazines were all quoted as sources of information about careers in engineering and science. Only 5 girls remembered finding the careers room at school a useful source of information.

When pressed to state the most important source of information about engineering as a career, 24 considered that informal talks to people involved in engineering had been most important, while 15 thought careers literature most important, and only 11 cited events at school or teachers as most important. On the amount and nature of careers advice at school only 5 girls thought that there was sufficient advice, while 29 girls thought there was not nearly enough. Many of the girls felt that top priority should be given to improving direct contact with engineers. Closely allied to the need for careers advice given by engineers was the need to visit industrial sites to see engineers in action. This result agrees closely with our finding that the most worthwhile component of the 'Insight' course programme is the day spent in industry alongside working engineers.

From these results it is clear that even for girls who ultimately opted for careers in engineering there were many problems and deficiencies within the education and careers advisory system at secondary school level. We feel that this lack of identification of physical science studies with any recognisable career goal is a major missing dimension for the vast majority of girls at school. This is particularly important since girls are more mature than boys in outlook and even at the age of thirteen or fourteen are beginning to feel their way into womanhood and looking towards their future roles in society. The inability of school teachers to explain the vital importance of competence in physical science and maths for many of the worthwhile careers that will be available to women in the future is a major problem. In addition, young school girls lack role models of successful women in science or engineering. The vast majority of physical science teachers are men and except in single sex girls schools where there are more women science teachers, the school girls find it very difficult to relate to their science teachers. Furthermore, men science teachers may well believe that girls are not suited to the study of physical sciences, and particularly not engineering or technology.

Thus, while there is a very important role to be played by changes in the content of physical sciences courses to make them more relevant to the interests and attitudes of girls, we believe that the direct input of information about careers for women in technology and engineering can also make a powerful contribution to changing attitudes. This information is best imparted by young women scientists, technologists and engineers in successful careers outside teaching. These women act as role models for younger girls and carry far more credibility than older male scientists and engineers (or male school teachers).

The Loughborough University School Link Programme

As explained above, we recognise that in the U.K. it is vitally important to change attitudes and increase knowledge amongst school girls aged 13-15 years concerning the relevance of technology to their lives. In order to test out our views on the value of using women in technological careers to impart information to schoolgirls, we have been developing contacts with local secondary schools. We aim to establish continuing links with the schools so that girls from thirteen years old onwards have direct access to the University project team. The links will continue over a number of years and we hope to encourage many more girls to continue with studies in physical sciences and maths and to have careers in technological fields.

Most of the local schools in the area of the University which take girls as pupils have agreed to take part in the programme. We have visited the schools to make preliminary contact with head teachers, careers teachers and science teachers. Generally, the first step in establishing the link will be to speak to groups of schoolgirls in the age range thirteen to fifteen, in the presence of their careers or science teachers. This process has already started although it will be some time before we have meaningful statistical information on the effects of the programme. We aim to both impart information and change attitudes.

The presentation consists of a short introduction explaining the aims of the programme, a fifteen minute tape/slide show which outlines career possibilities in technology at professional and technician level, and short talks by young women engineers or women engineering students. The tape/slide show places strong emphasis on the need for continuing studies in physical science subjects and mathematics for a worthwhile career in technology. The women engineers or engineering students who speak talk mainly about the reasons why they opted for careers in technology and about their experiences so far. These women tend to be enthusiastic and place stress on the interest and variety which they find in their careers, the opportunities for advancement, for travel and the relatively good pay and conditions of work. Usually, the rather large group of girls is then split into a number of smaller groups so that they can talk to the presenters informally. We also take some exhibition stands to the school with a good deal of information on them about careers for girls in technology. We feature photographs of women engineers and women engineering students prominently on these stands since pictures speak louder than words to girls of this age. Alongside the exhibition stands we place a variety of printed information about careers in engineering, technology and applied science, with the emphasis on the opportunities for women at professional, technician and craft levels.

We hope to establish links with the girls and with their teachers on a continuing basis. In this way questions which arise in the girls' minds as a result of the presentations can be followed up later. The girls are encouraged to contact the University Project Team, either through their teachers or directly, to obtain more information or talk further with us about their career aspirations. They can then be directed to contact University engineering, technology or science departments to talk to academic staff, arrange visits, or be sent relevant information. Alternatively, they can be directed to Loughborough Technical College to discuss careers as technicians or as craftswomen. We are also able to arrange visits by groups of girls to local employers to see the work of technologists in industry, or in public sector employment. The University has very close links with industry, and most local employers have a positive attitude towards women taking up technological careers.

Most schools have already agreed to put up notice boards where information relevant to girls interested in careers in technology can be placed. We expect to go into schools at least once each year to present our 'information package'. In addition, events will be organised at the University for girls of various schools with an interest in a particular area of technology (say computing or materials engineering) to attend with their teachers.

As stated above, we have already begun the series of presentations in schools, which started in June 1981. While it is much too early to report on the long term outcome of our contacts with schools, there are some preliminary observations which are worth making.

Preliminary Observations on School Links Programme

Firstly, we have found that the majority of teachers are initially in favour of the programme. Some are very concerned about the future career prospects for their girls, especially with the present high level of unemployment in the U.K. They recognise the need for a move away from the traditional women's careers (teaching, nursing and office work for example). Some of the more enlightened teachers recognise that there is no reason why girls should not be able to take up technological careers. We have also found that for science teachers in mixed schools there is a strong interest in encouraging more girls to take physical science subjects. This is because of the steady decline in the birthrate of the last twenty years which is leading to fewer boys being available to take physics and chemistry.

Unless more girls can be persuaded to take physical sciences (especially physics) the numbers in classes may drop below the size for realistic viability. This would inevitably lead to physics being largely dropped from the syllabus for older children, affecting boys' education as well as that of girls, and leaving teachers of physics with a very limited role. Evidence from discussions with (male) physical science teachers indicates that they place all or most of the blame for the negative attitude of the majority of girls towards physics and chemistry on the girls' parents and on society generally. They do not accept that the school experiences of girls have played any part in forming their attitude. We have found some hostility amongst teachers to our view that schools do discourage girls from taking a serious interest in physical sciences, if only by failing to stress positively to girls the importance of studying in this area.

We have so far found considerable interest amongst the girls themselves, even those who are already considering careers in other fields. Their level of knowledge about careers in applied sciences, technology and engineering is extremely low. It is therefore necessary to pitch the content of the session at a rather basic level, but to inject interest and enthusiasm into the presentation. Often, the girls are reluctant initially to ask questions and need encouragement from their teachers. This reluctance stems both from shyness and a desire not to show the severe limitations of their knowledge about the material we are presenting. However, once initial questions have been raised by the girls a vigorous discussion usually takes place. The girls ask their most interesting questions when placed in small groups with the women engineering students with whom they can more readily identify. They show a considerable thirst for information of all kinds, both personal information about the women engineers and more general information about careers.

We find that the girls are extremely keen to see all the printed careers literature that we take to the schools. Generally, they have seen very little of this material before, although it is all freely available from the professional institutions, industrial training boards, universities and colleges. This is of course a reflection of either the lack of time or lack of interest of careers teachers and science teachers in obtaining this material.

We have found a completely serious attitude amongst the groups of girls we have spoken to so far, even the younger ones aged only thirteen. This increases our conviction that girls of this age are ready to learn about careers which are as yet unconventional for girls to take up. We have discovered that girls of this age are keen to discuss with us their ideas for various careers outside the technological fields we are promoting. This indicates their desire to talk to anyone other than their parents or teachers who seems to be interested in careers for women outside the conventional fields.

From the initial reaction of girls to these first presentations we feel that the basic format is sound, and that the initial approach alone looks likely to have some impact on the numbers of girls deciding to continue with physical science subjects. The teachers seem pleased to have identified a source of information about technological careers which they can draw on in the future. The women engineers and women engineering students find the experience rewarding in itself and beneficial in helping them to learn to speak in front of an audience.

The most contentious aspect of this work is the way in which we are restricting the link to girls only. There is no doubt that many boys would benefit from the information imparted by the presentations and by links with the University staff and students. However, we feel that the whole thrust of the activity must be towards girls and concentrated on the role for women in technology. In a mixed group of boys and girls, the boys will almost certainly take the lead in discussion and may well scoff at girls asking very basic questions about technology. The girls on the other hand are likely to become very inhibited and unwilling to show keen interest in the presentation when a large number of boys is present.

So far teachers have accepted the idea of presentations being for girls only. However, they may be more reluctant to accept the idea of continuing links being available to girls only. Indeed, the Project Team has rather uncertain views on this, especially as regards older children, and it may be that in years to come some of the contacts and assistance will be for boys as well as girls.

Undoubtedly, the biggest problem for this programme will be finding sufficient resources to sustain the links after the initial schools presentations have taken place. Most of the women engineering students are only available during term time since they return to their homes all over Britain for the University vacations. The Project Team will be aiming to increase the interest and commitment of academic staff of relevant University departments so that we can confidently pass on enquiries and requests from girls and their teachers knowing that they will be dealt with properly. This is reasonable since the University departments have a good deal to gain from attracting a greater number of girls into engineering.

We will be following-up the outcome of the programme closely in order to justify the resources committed. The major interest will be in the extent to which the number of girls continuing with physical sciences and going into technological careers increase at each school.

The Future of the Loughborough Project

We hope to continue and expand the programmes described in this paper. There is continuing and growing interest in the U.K. concerning the issues of girls and science education, and technological careers for women. Loughborough University is becoming well known for its contributions to developments in this field. We wish to use our present reputation to attract careers advisers and concerned teachers onto a series of conferences and courses at the University. We are convinced that progress in this field will be relatively slow unless we can influence the attitudes of these staff and increase their knowledge about careers for women in technology. The two aspects reinforce each other since negative attitudes amongst teachers often stem from lack of knowledge. Indeed, we feel that teachers in general are at least as lacking in understanding that girls can be engineers or technologists as members of the general public. Indeed, because of their isolation from industry and the generality of working life, teachers may have a poorer understanding of the role of engineers and technologists at professional level than most people.

At the same time we are working on the development of literature about women in engineering and technology. Compared with the USA we still lack sufficient well presented and eye catching brochures and literature. Photographs of young women engineers and technologists at work will feature strongly in this material, as will case studies of the careers of women working in these fields.

Finally, so far as encouraging girls into technological careers is concerned, we wish to promote the work we have been doing so that others will be encouraged to develop their own activities. If most of the higher and further education institutions in the U.K. were to develop links to local schools to promote science and technology for girls, the vast majority of school girls and their teachers across the country would be involved. We therefore try to take every opportunity to publicise our work in newspapers, popular magazines, and journals, and on local radio. Women in engineering and technology is a subject with considerable news value which we seek to exploit.

We encourage all our women engineering students to talk to interested groups about their experiences whenever possible. Certainly, the vast majority seek opportunities to go back to their old schools and talk both formally and informally to younger girls and to teachers. We encourage them to talk particularly to head teachers, especially where the head previously had doubts about girls going into technological careers. We are helped in this by the fact that girls have so far done well on engineering degree courses at Loughborough University, so the students have a very positive message to pass on.

As explained in the introduction to this paper, the overall project is also very much concerned with the career development of women engineers and technologists. Our research shows that there are considerable problems to be overcome by women pursuing technological careers, especially with respect to career interruption for family reasons. A full discussion of our research and programmes in this field is beyond the scope of this paper. Suffice it to say that we are working on schemes aimed at minimising the difficulties of career development and continuation. This is very important since we are beginning to see signs of a definite upturn in the number of girls taking up technological careers in the U.K. The numbers are likely to accelerate in the next few years and it will be very unsatisfactory if a large proportion drop out of such careers at a very young age and do not return.

We feel that there is every prospect of women being able to have full careers in technological fields in the future, even if they marry and have children.

As part of our work we attend conferences and meetings to pass on the experiences we have gained so far and to learn from others. Although we have a considerable body of knowledge about relevant developments in the USA, our knowledge of progress in other European countries has been rather weak. We are therefore most grateful to the organisers of the GASAT conference for this opportunity to describe our work and to learn from other European colleagues about their activities in this vitally important field.

Acknowledgements

I am pleased to take this opportunity to acknowledge the contributions made by other members of the Project Team to the work described. Dr. Susan Bullivant of the Engineering Mathematics Department at Loughborough University has taken a leading part in developing the women's engineering student society and establishing links with local schools. Mrs. Pauline Marshall has acted as research and development assistant for all aspects of the Project described above and took a leading part in the interview research with women engineering students and 'Insight' applicants. Thanks are due to the University engineering departments and the Centre for Extension Studies are thanked for assistance with the Project, especially my assistant Mrs. Kathleen Gilbert.

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5. THE SCIENCE EDUCATION OF GIRLS IN CANADA

A Strategy for Change

by Janet Ferguson

Science Council of Canada

Ottawa

INTRODUCTION

You who are attending this conference have a special concern about increasing the participation of girls in the world of science and technology. It is unlikely, therefore, that you would be surprised to learn that technology is rapidly and radically changing the shape of society in Canada, as it is elsewhere in the world. This has been the result of technological innovation since the invention of the ubiquitous wheel. But the rate at which technological change is occuring has accelerated to an explosive pace, and the expression "new today and gone tomorrow" has come to represent a way of life. Future shock affects us in every area; in the workplace, where silicon chips are making jobs obsolete; in the home, where computers are about to become commonplace; in science, where the fundamental blueprint of living material, the gene, can now be designed and built to specification; and in medicine, where these genes can be used to produce life-saving drugs. A short time ago few science professionals would have predicted such developments within this century. Yet today they are accepted as commonplace by many people. We no longer even marvel at the social revolution created by the introduction of the birth control pill.

Yet, in the face of the obvious and enormous impact of science and technology in our daily lives, the majority of girls in Canadian high schools still do not choose to study science or mathematics. They apparently do not realize that at least a minimal understanding of these subjects might be important or useful to them in their lives. And, up to this point educational policymakers, teachers, parents, researchers, counsellors and other adults who have an impact on students' education, seem to have accepted this choice as natural and inevitable. The absence of girls from physics and math classes has not provoked much comment or concern. From the point of view of most adults, there is no problem regarding the science education of girls. In other words, our first problem is that nobody seems to care.

It is this "nobody cares" problem that is currently being attended to by the Science and Education Committee of the Science Council of Canada. The strategy which has been adopted to approach the problem is a natural and necessary consequence of the broader context within which this specific problem is being examined. Thus it will be helpful to outline the role of the Science Council of Canada and the nature and origin of its Science and Education study, within which the problem of girls and science is but one issue.

Deliberative Inquiry as a General Strategy

The Science Council is Canada's national institute for science policy research. Though funded by the federal government, it functions as an independent institution, rather than as a government department. Its duties are to assess our country's scientific and technological resources, needs and potential, to make recommendations to the Minister for Science and Technology, and to seek to increase public awareness of scientific and technological issues.

In 1979, the Council decided to establish a broad study of the state of science education in the elementary and high schools in Canada. This study was undertaken largely in response to a wave of criticisms which charge that Canadian science education is failing to develop students' appreciation of the personal, social, and national relevance of science. For example, one critic claimed that students were not being taught anything about Canadian scientific accomplishments or the impact of science on Canadian society while another warned that young scientists were not being prepared to respond to the social responsibilities of science,and that politicians and citizens were not being taught to deal with the many problems we face that have an underlying scientific basis.[1] Similar concerns about the purposes and practises of science education have been voiced in other countries as well.

Therefore the Science and Education study is designed to accomplish three major aims. The first is the establishment of a factual basis for describing the present state of science education in Canada. This documentation is clearly required if valid assessments of the criticisms are to be made. Secondly, an historical analysis of science education in Canada is being conducted in order to provide some perspective on the present trends in science teaching. A third aim of the study is to stimulate active deliberation concerning future options for science education among those responsible for curriculum design, and among all the other groups and individuals in society who have an

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interest in science education.

For a variety of reasons, both practical and theoretical, the strategy which has been adopted for use in the study is one of deliberative inquiry rather than simple induction from principle, or deduction from data. The practical reality from which the need for this strategy flows is that the Canadian constitution designates education as a responsibility of provincial governments. While aspects of this responsibility are delegated to local school boards, and teachers themselves, outside agencies, particularly those that operate on a national basis such as the Science Council, have no authority to prescribe educational procedures or programs. In fact, the success of the study and its potential impact on the teaching of science depend very much on the good will and cooperation of the teachers, school boards, and provincial ministries of education. Without this cooperation, it is impossible to gather the necessary data, and the conclusions which might ultimately evolve from such a study could easily be ignored.

But the deliberative inquiry method has theoretical validity as well. Unlike the so-called "hard" sciences whose ideal is the unravelling of everlasting truths of the physical world, curriculum research is most often directed at determining what kind of educational practises and goals are most appropriate in a particular place and point in time. This process requires that the concerns of a diverse group of people be taken into consideration. Michael Connelly and his colleagues[2] have noted that, in fact, every member of society, student, teacher, businessman, politician, parent, man and woman has a stake in the school curriculum. And the curriculum which is ultimately developed for use in schools is shaped by the various and often conflicting demands of these "stakeholders". While one group calls for a return to the "basics" of education, another wants to see more Canadian content in the curriculum and yet a third insists that the social relevance of science must be emphasized. One group demands equality of opportunity for all students regardless of sex or income, while another claims that alternatives must be made available to allow for the special needs of certain students. The science educator must somehow assess the relative importance of these claims at any one time. Establishing a reasoned basis for action demands that the stakeholders be willing to deliberate over the issues. As noted before, the relative importance of the claims of any one group may change over a period of time as the needs of the society within which the school operates evolve. Thus there is a need, for an ongoing process of deliberation, and for a somewhat flexible curriculum which is capable of being modified to respond to the new demands that develop.

The role that the Science Council has chosen to play in this process is that of stimulating and mediating active, reasoned debate, or deliberation, among the various stakeholders over several current issues in science education. In this way, the study is intended to reveal new directions and new opportunities for the future.

This deliberative inquiry strategy has three important components: the "stakeholders", both inside and outside the professional education community, must be committed to the process of deliberation; secondly there must be a reliable factual knowledge base upon which arguments can be based; and thirdly, there must be a range of issues and alternative courses of action which need to be discussed and examined. These three components are developing, simultaneously as the Science and Education study proceeds, and the issue of the participation of girls in science can serve as an illustration.

A Canadian Workshop on Girls and Science and Technology

The problem of encouraging more girls to study science and technology has emerged as one of the issues to be deliberated in the study. In February of this year, the Committee sponsored a one day workshop on the Science Education of Women in Canada. The workshop was attended by about 60 people from a variety of fields who are concerned about education, about womens problems in general, or about the problems of girls and women in science in particular. In line with the inquiry aspect of the deliberative inquiry process, this workshop was an attempt to document the present situation of girls in relation to science and technology in Canadian schools, and to examine some of the theoretical and practical issues with which you are all undoubtedly very familiar. The fundamental data which are needed to initiate deliberation of this issue are the enrollment statistics for girls in science classes across Canada. The attempt which was made to obtain these basic figures quickly revealed a rather unexpected problem; the statistics in many provinces were not available. No one, it appeared, had been sufficiently aware of or concerned about the absence of girls from science classes to attempt a systematic documentation of the matter.

Nevertheless, the data, though incomplete, reveal once again the absence of girls from physics and mathematics classes reported by researchers in many other countries.[3] There are more girls studying chemistry than physics and one province even reported more girls than boys in this subject. And again in common with world trends, the number of girls studying biology is larger than the number of boys.

Papers presented at the workshop examined the present theories regarding the causes of the situation. Dr. Meredith Kimball, a university psychologist discussed the evidence that purports to explain the absence of girls from science on the basis of biologically determined inferior mathematical and spatial-visual abilities. She concluded her presentation with the following statement:

"We have been asking the wrong question for too long. It is time to stop arguing about what sex differences in ability exist, how large they are, and where they come from. The question we should be focusing our attention on is why the difference in participation of women and men in scientific fields is so large, when the sex differences in intellectual ability are so small?"

Other workshop participants went on to discuss the importance of environment in developing an interest and ability in science in young girls. Dr. Fischer's paper outlined the negative feedback theory which suggests that inadequate early experience of scientific and technical activities leads to a feeling of discomfort and inadequacy when these areas are presented in school, which leads girls to avoid participating in them and further increases their lack of understanding of the subject. A concept of "approval addiction" was introduced and its potential effect on the involvement of girls in science was examined.

Practical aspects of the problem of interesting girls in science careers were also discussed, including topics such as role modelling, career expectations and awareness and guidance counselling.

Dr. Linda Erickson, recently participated in a study of Gender and Math/Science education for the British Columbia Ministry of Education[6]. She outlined some of the programs that have been developed to improve the participation of girls in mathematics in the United States, and discussed their potential effectiveness in improving the situation in science in Canada. The recommendations that were developed by the British Columbia study group addressed four educational constituencies:

1. Those responsible for curriculum development and policies were encouraged to draw up sexism guidelines and to develop and select curriculum materials with a science and society emphasis. The need for programs to improve the informal science knowledge of girls in elementary school was also noted. The possibility of establishing single sex classes of equal difficulty but using curriculum materials more relevant to girls was suggested.

2. Educational researchers were encouraged to study schools with usually high or low enrollments of girls in physical sciences for purpose of making comparisons. Longitudinal studies of individual girls to assess the value of a variety of cognitive, affective, and experiential factors in developing an interest in science were suggested. And the need to identify more precisely the

specific kinds of "commonsense" knowledge that girls may need and lack in elementary school was mentioned.

3. To those responsible for inservice training and preservice teacher education it was suggested that programs should be designed to help teachers examine their own expectations for girls and boys in science classes. The recommendations to this group focused generally on increasing awareness of the problem and of the importance of teacher attitudes.

4. Similar programs to increase awareness of the problem and of the importance of accurate and extensive career information in changing girls attitudes to science were suggested to the people responsible for preservice and inservice training of school counsellors as well.

Dr. Louise Marcil-Lacoste, a philosopher, summarized the events of the workshop. She focussed attention on three critically important ideas that had gradually developed during the course of the discussion. The "nobody cares" problem was singled out as the first and most urgent area of concern. Change in any area of the education system is difficult to achieve, especially when that change involves modifying long accepted ideas and attitudes. As long as the teachers and parents and other important adults remain unaware of the existence of a problem, and unconcerned about its consequences, nothing will change. This therefore, is the first problem which must be attacked, and the recent activity of the Science Council in this regard will be described later.

Secondly, Dr. Marcil-Lacoste outlined in clear and positive terms the need to adopt a pluralistic approach to the problem.

This concern had emerged as being of central importance in any strategy to change the situation in the course of the discussion which followed the workshop papers. Educators and other stakeholders involved in the planning of options must be aware of the multidimensional nature of the causes of the situation. This problem does not have one single cause which can be dealt with by means of single simplistic solution. A great many different factors operate to separate girls from science. The nature of these factors and their relative importance varies with the age of the child and her social and personal make-up. Activities that help to develop an inituitive understanding of scientific concepts may be very important to an elementary school child, but less so to a high school girl. Sexual stereotyping seems to be most powerful in early adolesence when the self image is fragile, and feminine identities are being established. At the same time, the effects of these factors interact. A child who is uncomfortable with scientific subjects and ideas is unlikely to be persuadedto study more science by career awareness workshops and role models. But perfectly competent girls with excellent science skills may need clear role models and career paths to persuade them that science can be an exciting and rewarding area for women as well as men.

The complexity of the problem requires that action at a number of levels of the education system be undertaken simultaneously, if real and enduring changes are to be accomplished. Too often studies report on the basis of single isolated experiments that role models are not

not important, that single sex classes or weekend career workshops are not effective, and that even girls who seem quite comfortable with math and science in elementary school lose interest and drop out of these subjects in high school. Taken in isolation from other influences, these results are confusing. But viewed in the light of the kind of interaction previously described, these negative results become more comprehensible. The approach ressembles that of the person who tries to solve a jigsaw puzzle by examining and discarding each individual piece. It is only when the interrelationship between the pieces is examined and tested that the overall picture begins to emerge.

And finally, Dr. Marcil-Lacoste put forward for consideration, the idea that the difficulty that is often experienced by researchers trying to pinpoint exact causes of the situation may result from the fact that this separation of girls from science grows out of what is *lacking* in their education and their daily lives, rather than from easily identified concrete obstacles. We look, in most cases in vain, for institutional rules that exclude girls from science classes and university faculties. Though formerly it was common to find girls' schools in which physics and chemistry were not being offered, these archaic institutions have largely disappeared. Yet still girls do not enroll in science classes, and it is easy for adults to conclude there is nothing more to be done. However, the problem may stem more from the things which are not there in their education; the lack of early experience of science, including the absence of science as an element in play situations; the lack of role models of older girls and women who enjoy and are active in science, yet lead successful social and domestic lives as well; the lack of career awareness and good guidance counselling to improve it; and perhaps the most difficult feature to articulate but of paramount importance is the lack of very simple day to day acceptance and encouragement by teachers, parents, and others. Most of the adults who have been successful in any area of endeavour can look back over the course of their lives and find one or two individuals whose encouragement and confidence in them, as children and young adults, awakened and sustained their awareness of their own potential. The individual components of this situation are impossible to define because they are as individual as the people involved. They may range from things as simple as a teacher's positive and encouraging tone of voice, to extensive financial and personal support. In any case, it seems that the separation of girls from science may result from a consistent absence of these support systems, and from the absence of other important factors in their experience. Changing this situation involves once again, changing attitudes. And as Dr. Rose Sheinin, keynote speaker at the workshop, put it, we are told that change in any form of prejudice proceeds with glacial speed on the time scale of human evolution. It is our concern, and our task therefore, to act as a catalyst to speed up this change.

Strategy for Change

The lack of public concern about this issue is being approached by the Science Council through a number of doors. The Council is planning to issue a formal statement of concern about the situation. This statement is intended to act as an alarm bell, to draw attention to the situation and to its potentially serious consequences for women and for Canada as a nation. As a result of this intent, the statement itself does not address the substantive issues in any depth. Therefore, proceedings of the workshop will be published under the title of "Who Turns the Wheel? Proceedings of a Workshop on the Science Education of Women in Canada".[5] This document provides the background data and information on which the statement of concern is based. It is available from the Science Council on request, but will also be freely distributed to a wide range of educational professionals.

The workshop on the science education of women in Canada was sponsored in an attempt to provide a documented basis for the further deliberation of this issue. It is one of several methods being employed in the Science and Education study to gather information about the critical issues of science education, including this one. A nationwide survey of science teachers is being conducted in the form of an extensive questionaire which is being distributed to over 10,000 teachers of science in schools across the country. Such a large scale study represents a unique opportunity to gather information on many topics, including the one presently under discussion. The questionnaire is designed to elicit information about such issues as the general level of education and experience of science teachers at each level of the system, the support facilities available to them, their goals in teaching science, and the conditions under which science is being taught. In addition, several questions aim at determining how teachers compare attitudes and abilities of the boys and the girls in their science classes. Taken in combination with the other data being collected this survey should yield valuable results.

At the same time, a series of 8 case studies have been organized to be carried out by educational researchers in selected schools across Canada. Each of these researchers will spend a total of three weeks over a three month period in the science classrooms of a particular school. The observation of classes and discussions with teachers will then be reported extensively and is intended to provide a more intensive and individual picture of the present state of science teaching in Canadian schools. These case study researchers have met and discussed the guidelines and emphases to be considered in their observations. It is their intention to observe the interactions between teachers and students both male and female as one of the study's concerns. At the workshop it was pointed out that student teachers are often surprised to discover that they have directed most of the questions in a practise teaching lesson to the boys in the class. Therefore case study's researchers will be looking for subtle forms of bias operating in the classroom, which may have powerful long-term effects and are difficult to document through other forms of research.

Other research activities are underway to provide further information about what is happening in science classes in our schools. The most commonly used textbooks are being examined to determine what emphasis they place on such issues as Canadian science achievements, and the social applications of science. Provincial curriculum guidelines are also being studied to estimate the relative importance the various Ministries of Education have assigned to such topics.

All of these research methodologies, the teacher survey, the case studies, the textbook survey, the curriculum guideline study, the historical analysis, and the workshop constitute the inquiry aspect of the deliberative inquiry strategy. Taken together, the results of these activities should provide a formidable data bank upon which deliberation can proceed and future options for science education can be developed.

The deliberative phase of the deliberative inquiry is being conducted simultaneously but by rather different means. A series of discussion papers[6], typically written by people outside the formal elementary and secondary education system have been commissioned by the Committee. Each of these papers examines and criticizes contemporary science education from the perspective of a particular stakeholder. Possible changes for the future are presented. Each of the papers published to date presents a unique perspective, and the issues discussed range from "An Engineer's Perspective on Science Education" to "Science in Social Issues: Implications for Teaching". These papers are disseminated to all who request them, and discussion by those within the education system (as well as those outside it) is encouraged. The papers are supported by a regular Bulletin published by the Council and distributed widely throughout the system, four times a year. The Bulletin documents recent activities of the Science and Education study and discusses other publications and events of interest to science educators.

With respect to the issue of the science education of girls in

Canada, the published proceedings of the workshop are expected to function in much the same way as a discussion paper. The proceedings will be distributed among the same wide community of educators as the other discussion papers, and to those others who have a stated interest in science education. All recipients are encouraged to take an active part in discussion of the issue and to communicate their ideas and impressions to the study committee.

The deliberative inquiry method is especially suited to dealing with a problem in which the raising of public concern is of primary importance. Wide distribution of the documents ensures that the issue will come to the attention of a large number of people. The discussion and argument which is generated by the papers, which are intended to be controversial and open for debate, stimulates further and more active interest. And the potential for input of ideas to the study group which might influence the recommendations of final report, tends to further encourage active consideration. The strategy is intended to emphasize that the planning of educational goals and methods of the future is a business in which all educators can participate. The fact that these publications are addressed to all levels of the education system from the elementary schools to the Ministries of Education, means that the issues can be considered at a number of different levels at the same time. This opens the way for each section of the system to generate appropriate responses to the problem at the same time. It may be overly optimistic to suppose that this is likely to occur rapidly, but the potential for action to be taken at a number of different levels at the same time is maximized.

The Science and Education Committee is presently considering the possibility of establishing a small ad hoc group of interested and involved individuals who would recommend further activities to be undertaken by the Council in this area. As previously noted, the Council has no formal or direct authority for dictating changes and directions within the education system. Nor does it function as a granting agency which chooses and funds specific research projects. The Council relies for its impact on its reputation for producing carefully researched and valid information. In this capacity it is well respected and has a wide audience for its publications and statements. There is good reason to suppose that the conclusions of the Science and Education study will have a real influence on the science education policies and practises of the future. The interest of the Science Council in the science education of women has already generated some interest in improving the methods whereby enrollment statistics are kept in a number of provinces. The workshop proceedings recommended that such information would be useful and should be facilitated by the use of computer technology. Difficulties do arise when attempts are made to integrate enrollment in some of the new science-based courses such as environmental studies and agricultural science into the data collection. These courses are not universally available as yet, though the number and range of courses of this nature is increasing. Also, it is unclear which of these new courses may be accepted for university entrance purposes. A strategy for collecting and organizing this information needs to be developed.

At the moment, Science Council activities centre on increasing awareness and concern about the situation, a necessary step in changing attitudes in any setting. Dr. Sheinin claimed that the collective philosophy of our society, which is experienced first and most powerfully in the home environment, teaches young girls that women are not welcome or needed in the workplace and particularly not in the scientific workplace. Schools, churches, the media and friends reinforce this message as a child grows up. As a result, a cycle has been established in which men and women marry and have children. These children grow up and go to school, get degrees or diplomas and eventually enter the workforce. Then they in turn become the mothers and fathers of the next generation, and so the wheel of fortune turns and turns. This wheel which carries many boys on to careers in science and industry seems still to leave the girls behind or turn them in different directions. What we really need to ask is "Who turns this wheel, and in what direction?"[7] The Science and Education Committee in attempting, through the process of stimulating deliberative inquiry of the topic, to provide some answers to this question, and to foster an atmosphere which will help to turn the wheel in a new direction.

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6. TO ATTRACT AND HOLD YOUNG WOMEN'S INTEREST IN THE PHYSICAL SCIENCES (SO THAT THEY CAN ACHIEVE SUCCES EQUAL TO THAT OF YOUNG MEN)

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Researchers working with very young children of both sexes find them to be very interested in and curious about the world around them and in number puzzles and games. These are certainly traits needed for success as a scientist. Since these traits are found in very young children we have to examine closely what happens to make them disappear in many young adolescent women.

Psychological and sociological studies have shown that the family, the school and society at large put constraints on girls which tell them overtly and covertly that science and mathematics are really masculine subjects[2,3,5]. They are told further that to be a successful "lady" one doesn't need to be or even want to be interested in or successful at these subjects.[53]

The family which is the first formative influence on the child gives small girls "feminine" toys and rewards for being "a little lady" in dress, thoughts and actions[4,24,38,49]. Girls are told explicitly or implicitly that "success" for them is "successful marriage".

The school, another formative influence, reinforces this pattern by having cooking and sewing courses scheduled for the girls but shop classes for the boys[42,54]. The teacher is often an even greater influence in placing a student into a girl or boy mold[39,58]. This influence is further reinforced by the textbooks which show boys doing and girls watching. If girls are shown doing, it is a "feminine" job such as cooking, cleaning or helping. Mommies stay home to take care of the family's needs and do the housework. Daddies go out into the world and have important jobs.

Despite these influences, during the elementary school years many girls do as well or better than boys overall, and even in mathematics. 8,4,7 However, during the middle school or junior high school years, due to previous influences of sex-stereotyping and the heightened awareness of the opposite sex and the societal pressure of "not competing" the girls'[43,60,71,77] grades drop. These young women do not elect further math courses which develop the necessary skill and knowledge for high school and college science and technology.[33] Unfortunately, this math avoidance is not opposed by parents and guidance counselors but, on the contrary, most often is bolstered by these adult influences.

In the United States several important steps are being taken to correct the situation. Recognizing the problem as starting early in childhood, groups of concerned parents, teachers, school administrators and community leaders successfully convinced the publishers of textbooks to prepare materials that meet criteria of fair and equal representation. As a result of these meetings the Association of American Publishers has issued a statement that it is committed to the development of material that is bias-free as to content, illustrations and language. The Fair Textbook Resource Guide of the United States Commission on Civil Rights Clearinghouse Publication 61, December 1979, includes this statement at the head of the index of the materials listed.[25]

The science instruction at the junior high level should be of the highest quality to raise the level of scientific awareness in the general population (those who will not study science further but will be the voting public for science funding) and to attract and retain those whose interest and skills will lead them to science professions and science-related careers.

The inadequate scientific preparation and consequent lack of positive feeling toward science on the part of elementary and middle school teachers are, to a large degree, responsible for the declining interest and enrollment of young women in science courses later in their careers.

There was a critical need for pre-service and in-service science education, both as perceived by the teachers themselves,[50] and as indicated by the research studies.[17,34]

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It has been found that the bulk of science instruction for the secondary program is in the junior high school, that nearly 50% of the students take no science after tenth grade. Yet it is the junior high school teacher who has the least adequate content preparation and the poorest facilities.

The National Science Foundation in recognition of this inadequate teacher preparation funded and sponsored many varied science courses for prospective elementary, middle and high school teachers.[23,29] (See Appendix) In addition to these pre-service programs there were many in-service programs planned as well, so that scientific literacy could be gained by the teachers and then imparted early in the educational process to their students.[30]

Better career education and counseling at the middle and junior high school level is needed to encourage more young women to plan for science careers when it is still early enough for them to see the need and have the time for taking the mathematics courses for the higher level science subjects to be taken in high school and college to fulfill these career plans.[26]

Some schools were found to be very effective in persuading young women to attempt high achievement in mathematics. Casserly (1975) identified 20 high schools which consistently placed an unusually high percentage of these students in advanced placement mathematics and science classes. Her study of these schools found that there were several common features: (1) these girls were identified as early as fourth grade (2) teachers had science, math or engineering backgrounds rather than "education" training alone (3) the teachers communicated a love of and enthusiasm for their subject (4) bright students were grouped together in math classes (5) teachers placed a great deal of emphasis on reasoning (6) teachers were supportive and acted as counselors for the students.[14]

Furthermore, based on psychological studies showing peer pressure[94] against female competitiveness against males, it has been suggested that all girl classes might produce more successful math and science students.[76] "Math for Girls" an eight week course for 6-14 year old girls conducted by Nancy Kreinberg and Rita Liff at the University of California, Berkeley, is a good example. Studies have shown that teachers react differently to boys and girls in the classroom as to attention paid, behavior toward and expectation from.[46] If there are only girls in the class, it would eliminate these biases. Although this might seem to be a step backward, segregation never being seen as good, it might be helpful for some small time period in the educational process when "fear of success" is an important psychological factor.[9,36]

One tends to do those things one feels confident in doing and to avoid those which produce anxiety. This seems to be the dominant factor in sex-related differences in mathematics learning.

In the United States there are now several colleges and universities which have established mathematics anxiety clinics to persuade teachers and students that math abilities are attainable by most students if properly taught and with adequate emotional support. (Wellesley College in Massachusetts, Wesleyan University in Connecticut, Georgetown University in Washington, D.C. and Mills College in Oakland, California, to name a few.)[74]

In conjunction with these clinics, some excellent texts have been published: (1) Math Without Fear by Dr. Carol G. Crawford, (2) Mind over Math by Stanley Kogelman and Dr. Jos. Warren and (3) Overcoming Math Anxiety by Sheila Tobias.[19,41,67]

However, from what we know about the need for math as a preparation for science, it would seem that they were working at the wrong end of the educational process. The previously mentioned "Math for Girls" if introduced at the entry level might better correct this problem.

From 1956 on, there was more interest and activity related to development and change in science curricula and instructional materials than any other equal time period in the educational history of the United States.[23,51,52,63] The National Science Foundation funded the Physical Science Study Committee (PSSC) to produce materials for a new high school physics course. Professional scientists from universities worked with high school teachers to replace rather than revise the curriculum. This was a revolutionary move and, similar to many revolutions, had mixed results. On the positive side, the specified curriculum was more discipline oriented with a greater emphasis on (1) in depth concentration on a few concepts (2) the scientific method and (3) hands-on laboratory experience. On the negative side there was (1) less flexibility for both teacher and student and (2) many courses were constructed so that they were too difficult for the average teacher to present and the average student to learn.

I personally was involved in teaching high school physics for several years, both the "old" or traditional curriculum and the new Physical Science Study Committee Physics.

The new curriculum had many good features: (1) The experiments were well devised with fairly simple equipment so that even the smaller, less affluent schools could use the program (2) The films produced for use with the course were superb. (3) It deemphasized memorization and a great deal of technology. But all technology was omitted, even calorimetry which many students in earlier courses had enjoyed as a topic relevant to diet.

I took the Summer PSSC teachers' course sponsored by the National Science Foundation before I taught the program. Although I had been a physics major at college, I felt that there would be new techniques for teaching this course and I wanted to preview the films and do some of the experiments myself.

It was an excellent course when taught by a knowledgeable teacher to mathematically well prepared students. Unfortunately, not everyone who taught the course had the necessary background and training and many students were inadequately prepared. The results, therefore, were not as consistently good as had been hoped for.

The National Science Foundation also funded an elementary school science curriculum program, Science Curriculum Improvement Study (SCIS). It was essentially an "inquiry-oriented" program, one structured around a method by which the student attempts to solve a problem. It involved a teaching style and special techniques of working with children which hoped to establish a classroom environment conducive to the development and enhancement of a child attitude toward science emphasis.[40]

The National Science Foundation has most recently funded the Development in Science Education (DISE) Program to increase the quality and diversity of science education. One of its main goals is to focus attention on the middle or junior high school, with the realization that this important period in schooling has been bypassed, concentration having been placed on the elementary or high school.[15,37] The emphasis now is to make the science curriculum relevant to the daily life of adolescents, exciting their curiosity and responding to their career planning concerns.[48]

I did an extensive literature search for this paper, reading about research on the psychology of women, curriculum studies, etc. From what I've read, I am convinced that there is a great deal that can be done to attract and hold young women's interest in the physical sciences so that they can achieve success equal to that of young men.[32] Essentially, it is early identification and proper emotional development so that society does not lose half of its quality, creative human resources.[10,12,18]

First of all we must try to convince parents that baby girls should not be treated differently from baby boys. Mothers and fathers should be equally expressive, instrumental and supportive to children of both sexes. A mother should not tell her daughter that she doesn't need to know or be proficient in math and science. The father should buy and encourage the use of jig-saw puzzles and structural toys such as Tinker Toys, Erector Sets and models. It is especially important in this age of "watching" (television and movies) that girls get involved in doing. Both parents should foster a high degree of independence and self-assertiveness, letting the daughter take the initiative in solving problems for herself and developing the same analytic abilities as her brother.[7]

Researchers have found that self-concept or self-esteem are related to a great extent to academic achievement.[64] Therefore, young women should be allowed, and more than that, encouraged to develop success early in the educational process in order to be successful later in achieving careers in science.[20,21,31] Rosyln Yallow, a physicist by training and Nobel Medalist in medicine, has stated that creativity has an element of deviancy and unfortunately most girls and women are trained to be conformist.[34,45,73] If one expects a young woman to be independent with a high degree of self-esteem and confidence, this has to be fostered very early in her life. Her teachers, and especially those teaching science and math, must be secure in their roles so as to act as role models and must not treat her differently or expect less of her than her male peers.[56,57] Her textbooks should not in any way lead her to perceive herself as less capable of doing all the things young men can do.[27,28] Her guidance counselors should be bias free so that they can encourage her to take math courses and science courses so that her career options are expanded. Our society must change from thinking of math as a masculine attribute.[55] Judith Bardwick in her "Psychology of Women", 1971, has said that "if the self-esteem of women is to be enhanced either the socialization of girls will have to alter so they acquire the necessary 'masculine' qualities of independence and assertiveness or the values of society will have to change so that 'femine' humanistic goals become esteemed or both".[5] Men and women need role freedom.[16,66]

Early adolescence is a crucial period in science education for the immediate future of the student and for the long range future of scientific discovery.[22] Therefore, we, as science educators, must exert our efforts to develop and implement those character traits and curricula which will best serve these aims. We will need the help of all society to change the environmental factors as well which are the barriers to the full realization of the potential of girls and women. When we do this, we will have achieved our goal of producing as many qualified women scientists as men.

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7. REPORT OF SCIENCE EXAMINATIONS AND THE TYPE OF SCHOOL

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My concern for girls' science and technology education derives from experiences during many years as a science educator.

I taught in both girls' and mixed grammar schools in the two decades following the last war. In the girls' schools, where facilities to study science were often barely adequate, the girls would choose physics and chemistry in numbers comparable to those choosing arts subjects if it was made clear to them that the sciences were acceptable subjects for them to study. However, in the larger, mixed grammar school, which had well-equipped laboratories, very few girls were to be found in physics and chemistry classes after the age of 14 years.

Later, when I worked in a teacher training college, I found the young women training to become teachers for primary schools felt alienated from the physical sciences. They commonly claimed they hadn't been good enough to 'do' them, and had little confidence or incentive to try again. I had to start from where they were at the time. Several were at the stage of learning to drive and one of the most enjoyable courses I ran was 'The Science of the Motor Car'. Some were specializing in music and so we looked at the science that could be derived from simple music activities in the Infant school. Many times I heard them comment, 'Why couldn't we have learnt science like this at school?' This made me aware of the arid nature of the courses that most of these young women had experienced at school and the need to change the image of school science.

After the introduction of Nuffield Science courses into secondary schools in the 1960's I was part of a project enquiring into the extent of their use and the factors which influenced this. These new courses were used more extensively for boys than for girls and I found that some teachers (but by no means all) claimed that girls had more problems with 'the Nuffield approach' than did boys. These teachers had clearly-defined assumptions about different characteristics and abilities possessed by the two sexes - were they right?

I was able to follow this up by studying the performance of boys and girls in the special Nuffield science examinations at GCE 'O' level, comparing them with more traditional courses and examinations. I found no significant differences between boys' and girls' overall successes in any of the six examinations included in the study, whether the courses were 'Nuffield' or more traditional. But two sex differences did emerge from more detailed analyses (1) in the relative success of boys and girls when different modes of assessment were used (boys tended to achieve higher mean scores on tests containing multiple choice, fixed response items, while girls did better when extended answers were required) and (2) when sub-groups by type of school were compared, girls in girls' schools did better than girls in mixed schools, who also achieved fewer percentage passes than the boys from these schools. A similar effect was not found for boys. (Harding 1979). I wish to comment further on these two relationships.

Mode of Assessment

Several studies have confirmed a sex difference in response to mode of assessment. Ferguson (1977) showed that when London University School Examinations Board included a multiple choice paper in its 'O' level Biology examination boys obtained the higher mean in this paper, while girls did better than boys on the essay paper. When the Associated Examinations Board changed its Geography syllabus and at the same time introduced a multiple choice paper a sex difference was obtained, with boys suddenly increasing their pass rate by ten percentiles. Murphy (1980) detected the origin of this difference largely in performance in the multiple choice paper. He has gone on to show (Murphy 1981) that in most AEB examinations that include a multiple choice paper as well as one in an alternative mode boys improve their performance relative to girls in the former when comparisons of scores on the two papers are made. Murphy suggests that the effect may arise from a linguistic disadvantage suffered by boys. There is a tendency to assume that as the multiple choice mode is free from the subjective bias of a marker, it provides a more reliable mode of assessment. But we know little about the skills required to achieve success in the differing modes of assessment, nor whether the skills we reward are those of most value in later life.

Education consumes large resources and nations are currently responding to accountability demands by attempting to monitor pupils' educational performance. This coincides with technological advances which make machine-marked testing an efficient and economical technique. In the U.S. the National Assessment of Educational Performance has used machine-marked tests exclusively and has found that females achieve less well at all ages tested and in a wide variety of subject areas. There is a danger that performance may become equated with ability: it is therefore important that we understand what gives rise to these sex differences.

The relevance of this discussion to the study of science lies in the increasing use of multiple choice testing, especially in the sciences, as feedback to the student of his or her mastery of material as a course develops and in recording final achievement. If the mode contains an inbuilt disadvantage for females their self-image of proficiency in science will be further depressed. More carefully planned research is needed to determine the skills candidates employ to achieve success in formal testing and to identify any disadvantages suffered by special groups. One small study which attempts to isolate the mode from a knowledge variable is developing at Chelsea College.

Mixed or Single Sex Schools?

Readers may know that from 1965 secondary schools in England and Wales have slowly become reorganized to accept a comprehensive intake. Prior to this, some 20% of pupils, boys and girls, were selected by ability tests at 11+ to attend grammar schools, while most young people completed their education in 'secondary modern' schools created by the 1944 Education Act. (Some priviledged children were (and still are) educated in Independent or 'Public' schools, where fees are payable. A few Local Education Authorities provided Technical schools for 13-16, 18 year old pupils, although the proportion of pupils attending such schools was small). An additional change accompanying comprehensive reorganization was that schools which had provided for boys' and girls' education separately (single-sex schools) were frequently combined to form mixed or coeducational schools.

The issue of whether to educate girls and boys together or separately had been under discussion for many years in England and Wales. R.R. Dale (1974) was a staunch supporter of coeducational schools. He assembled data to show that, among grammar school pupils, both sexes benefitted socially and that boys achieved better academic success in mixed schools. The data for girls were not so clear-cut, indeed, in science, it appeared that girls might be more successful in girls' schools. Ormerod (1975), using a limited sample containing, however, both grammar and comprehensive, mixed and single sex schools, showed that attitudes, to science, were more polarized between the sexes in mixed schools. Physics, for example, was a moderately popular subject in both boys' and girls' schools, whereas in the mixed schools in his sample physics was very popular with the boys and very unpopular with the girls. The choice of physics as a subject to study was similarly polarized.

A survey carried out by Her Majesty's Instpectors (HMI, 1975) supported these results, showing that although fewer girls had an opportunity to study physics in girls' schools, when it was available nearly a quarter of them chose to study it in years 4 and 5 of the secondary school [1] (14-16). On the other hand a higher proportion of girls were offered physics in mixed schools, but fewer of them chose to study it. (See Table 1, Appendix B). It was apparent that a complex interaction of opportunity and expectation was operating on girls' choice of science.

A more recent survey of secondary schools in England (HMI, 1979) has led the Inspectors to claim that the differential choice of physics in mixed and single sex schools no longer operates in comprehensive schools, but was a feature only of the selective system . (See Table 2, Appendix B). However, the number of girls' comprehensive schools in their sample was rather too small to warrant reliable generalizations.

The issue is, I believe, a complex one. I have argued elsewhere (Harding 1979) that it is not the type of school per se that matters but the expectations of girls found within a school.

The history of girls' education in England and Wales shows that two clear ideologies have operated. More than 100 years ago a movement arose to give girls an education equal to that of their brothers. Prestigeous schools were established and many of the girls' grammar schools of the first half of the century derived from these or were staffed by women educated in them. In such schools wide horizons were offered to girls and no future success appeared barred to them.

On the other hand for the majority of average or less able girls not attending grammar schools a different expectation operated. This was clearly expressed by Newson (1948) in his 'Education of Girls'. He assumed, at that time, that girls' education should be different from that of boys. The former should be prepared for their roles of wives, mothers and homemakers, whereas the latter should be trained as bread-winners or wage-earners.

Most secondary modern schools for girls contained a room for the study of biology and facilities for domestic science, but few, if any, possessed physics or chemistry laboratories. The figures in Table 1 reflect the effect of this in the small number of average or less able girls studying the

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1. Readers are directed to Appendix A for a brief account of subject choice and the examination system in secondary schools in England and Wales.

physical sciences in such schools. Comprehensive schools are obliged to provide more laboratories than modern schools, but the official laboratory requirement in girls' schools was less than that for boys' and mixed schools until Equal Opportunity legislation was passed in 1975. However, financial restrictions operating over recent years has meant that changes are slow and there are many girls' schools still with inadequate laboratory or staffing provision. If a comparison is made between the figures for girls and boys provided by the HMI (Table 2 and 3, Appendix B) it can be seen that boys have benefitted from an increased provision in science in comprehensive schools, but girls have not.

When comprehensive schools were formed more grew out of modern schools at a time when the age group size was increasing, than were formed from amalgamations of grammar and modern schools. The dominant ideology for girls' education in comprehensive schools, whether mixed or single-sex, was likely to be that appropriate to the bulk of the pupils - reflecting the stereotype of female behaviour. However, pockets of the 'equality' ideology have persisted and can be found in individual schools. In work developing at Chelsea College it is becoming apparent that girls' performance in science is strongly influenced by the school 'ethos' and the expectation of girls that this subtly conveys. It is significant that many of the schools in which girls study the sciences and achieve well in them have grown from girls' grammar schools. Several schools in the London area which are currently changing from single sex to mixed schools (as a result, this time, of falling rolls) are collaborating in a study to monitor the progress of equality of opportunity for boys and girls within the curriculum.

Initiatives taken by the Association for Science Education

The Association for Science Education, a professional body of over 17,000 science educators, has expressed public concern over the problem of girls' science education since the early 1970's. Its Education Coordinating Committee has supported two subcommittees, the first brought the issue to the attention of members and culminated in a symposium held at the Annual Meeting in January 1976. As a member who had initiated research into the problem, I was asked to organize the first symposium and to chair the subsequent subcommittee (Girls and Physical Science). This set out to publicize among members strategies which teachers were already using in attempting to meet the problem, which had now been identified as the small number of girls, relative to boys, choosing to study physics and chemistry[1]. Two accounts have been published in the bulletin of the Association 'Education in Science' (April 1979 and April 1980). The former described how a head of science set out to convey to girls and their parents the school's expectation that girls are just as capable in the study of science as boys are. He chose girls to demonstrate physics and chemistry experiments when parents toured the laboratories on open days. A keen photographer, he took pictures of girls when they were busy operating equipment, enlarged them and displayed them in the corridors of the school, so that girls could become familiar with themselves working as scientists. It was important, he claimed, that there were some women teachers of physical science and that all teachers in the school shared the concern that girls should choose science. Unfortunately, if subject departments are in competition with each other for able pupils, this may not be so and is one consequence of the option choice system operating in schools in England and Wales.

The second report was of a girls' school, about to join with a neighbouring boys' school, which realised that it was providing an inadequate education for its girls in science and that this would possibly influence provision in the future mixed school. The combined efforts of the local authority science adviser (himself a member of the GaPS subcommittee), a new head of careers (a woman historian) and a temporary head of science (a woman biologist who regretted not being able to study physics at school) resulted in all third year classes of girls being shown a tape/slide presentation of the importance of physics for future jobs in the term before they had to make subject choices. They were asked to discuss with their parents which sciences they wanted to study and to make a provisional choice, ostensibly to help the science department to plan courses, but in reality to force the girls to think about science before they were faced with choices between subjects. The outcome was that 52 out of 150 girls chose to study physics, whereas none had done so the year before. Resulting fourth year physics classes in the mixed school contained equal numbers of boys and girls.

A grant from the Department of Industry enabled ASE to make multiple copies of the tape/slide sequence, so that these could be generally available for use in other schools. Many used them during 1981, not all with the marked success of the original school, but in the latter case several factors assisted in focussing attention and concern on this particular problem at the time it was first used.

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1. The trends of subject choices during the 1970's, as illustrated by public examination entries, are shown in Figures 1 & 2 in Appendix A.

The ASE (1981) has issued very recently a major policy statement in which it condemns the present option system that requires children to choose between physics, chemistry and biology or, in choosing all three (which only 10% of boys and 5% of girls do - HMI, 1979), distort an individual's general education.

The Girls and Physical Science Subcommittee of ASE organized a symposium at the 1981 Annual Meeting. This was attended by some 140 teachers and others. The tape/slide sequence mentioned above was shown, strategies used to attract girls to engineering were described by Dr. G. Chivers. These included the Engineering Industries Training Board's initiatives: 'Insight' in which Sixth Form girls, uncertain about which direction to go in a science career, are invited to spend a week in one of several University Engineering Departments, and their provision of scholarships for girls to train as engineering technicians, which has been running for several years. Hopefully, Dr. Chivers will attend the GASAT Conference to provide more details of these.

A colleague of mine, Dr. John Head gave an account of work he had carried out on the personality development of adolescents, from which he derived suggestions for changes in the science curriculum. Head used a framework derived from Marcia's work in the U.S. In this it is assumed that the major task facing the adolescent is that of achieving a mature ego identity from the diffuse ego of childhood. Two processes are postulated: those of commitment to ideologies or values and of crisis, where values and beliefs are questioned. Through the operation of both these processes a mature ego may be achieved. The pathways that individuals follow, however, may appear very different. (See Appendix C, Figure 3). A young person may seem to rebel, questioning and throwing over all beliefs and values inherited from parents or other sources in the small world of childhood. This is described as a state of moratorium (path B). Another person may proceed by path A in which questioning and commitment occur gradually, with no major upheavals. Others may continue to accept the values of their parents or immediate circle without question, in a state known as foreclosure, until some change, such as leaving home to attend university, disrupts their security, when a period of questioning may lead them to commitment to personally held beliefs and values (path C). Some, particularly those in a protected or isolated community, may never challenge the status quo and remain at the foreclosure stage (path D)(Head 1980)

To relate this model of adolescent development to science choice, one needs to examine the science presented to young people. If this carries a male image, which is also unemotional, impersonal and abstract, as much of school physical science appears to be, (Head, 1979) few young people who are proceeding by paths A and B, and to whom personal and social issues are important, will be persuaded to choose it. On the other hand, to a boy at the foreclosure stage, accepting traditional values, science may appear an obvious choice, and perhaps an attractive one, if it offers a safe, unemotional alternative to the personal turmoil threatened by adolescence. Some of these boys, beginning to question earlier values as they proceed by pathway C, will tend to change their commitment to science, perhaps accounting in part for the 'swing from science' detected amongst university entrants. Girls at foreclosure will choose subjects appropriate to their stereotyped sex roles (unless, in the protected environment of a girls' school, science is presented as an acceptable choice).

Head argues that if we wish to attract more able, thoughtful young people of both sexes into science we must show that its study is relevant to the real world problems with which they are beginning to grapple. Other research (Ormerod, 1975 and Ahlgren and Warlburg, 1973) have found that girls who choose science recognise its social relevance more strongly than do boys. In the light of this an invitation was made to teachers at the symposium to join in a curriculum development venture to prepare modules of work for year 3 pupils which will develop an understanding of science from its applied and social aspects. To date, twelve development groups have been set up in different regions of England and two modules, electricity and metals, which carry a strong masculine image, are planned.

Girls and Technology

The school subjects which show the greatest sex bias in the secondary school are those which have in the past been classified as 'Craft': the 'heavy' crafts such as woodwork and metalwork, traditionally chosen by boys and 'domestic' crafts such as cookery and needlework designed for girls. Since Equal Opportunity legislation in 1975 some coeducational schools have provided 'mixed crafts' for boys and girls during some part of first, second and third years of secondary schooling. During the 1970's, also, some woodwork-metalwork courses began to change. They expanded to include work with 'modern' materials such as plastics and objectives changed from emphasis on the finished product to broader educational aims embracing problem-solving and decision-making. These changes have been reflected in a change in the title of the subject offered by some examination boards, e.g. separate 'Woodwork' and 'Metalwork' at 'O' level have been replaced by a single subject entitled 'Design and Technology'. Departments in schools servicing these courses tend to be referred to as CDT departments (Craft, Design and Technology). But few girls' schools contain such departments, or even a workshop and so girls attending them are deprived of opportunities to develop problem-solving and decision-making skills. On the other hand, the move to provide girls with workshop experience in mixed schools is by no means universal. Even where this is so in early years girls still avoid the choice of Design and Technology in years 4 and 5.

Several projects have been initiated to raise the status of technology in English schools, for 'Craft' courses have traditionally been used only for average or less academically able pupils. The Schools Council 'Project Technology' was one of these. More recently the DES have funded research based at Oxford University Department of Education to develop technology in years 1 - 3 of the secondary school. Neither of these has focussed particularly on the problem of girls' technology education. However, British Petroleum have funded a Research Fellow, based at Chelsea College, under my supervision, to look more closely at girls' Design and Technology Education. The project will work with both girls' and mixed schools and three chief aspects will be explored. We plan to identify good practice where it occurs and investigate its transferability to other contexts. In this way we hope to sharpen understanding of processes hindering good practice. We will examine the objectives put forward for CDT courses and attempt to identify the minimum facilities where none exists at present, required to achieve the new educational objectives for girls in girls' schools. Finally we are setting out to plan a course in 'Materials Technology', leading to a 16+ examination, containing elements of existing courses in physics, chemistry and design and technology.

Postscript

After many years of wrestling with the problem of girls' science and technology education, I am convinced that the cause lies in the expectation a society has of its women. Much patient effort will be needed to bring about change. Indications are that some strategies for change may be superficial and ineffectual in achieving real changes in attitudes and behaviour. We need to monitor programmes carefully over a period of time and to continue to exchange insights and accounts of our several experiences in different national and cultural contexts.

Appendix A

Public Examinations and the subject option system in schools in England and Wales.*

Public examinations in England and Wales are not administered by the state, but by autonomous examination boards. There are two groups of boards:

1. Boards administering the General Certificate of Education (GCE) which replaced the School Certificate and Higher School Certificate in 1951. The latter examinations had been designed to test the achievement of pupils in grammar schools and both were group-subject examinations, i.e. candidates were required to pass in a specified minimum of subjects selected from particular groups in order to obtain a certificate. The GCE offers a single subject entry examination. Fees are charged, there are no age restrictions and candidates may enter privately or be entered by their school or college, in which case the fees are paid by the Local Education Authority. Examinations are provided at two main levels: Ordinary, 'O' level, normally taken by pupils at 16 years after five years of secondary education, and Advanced, 'A' level, taken by pupils at 18 years after a two year course in what for many years has been known as the 'Sixth Form'. Papers at two other levels are offered: Alternative Ordinary, 'A/O' level, providing a more mature approach than the common 'O' level, and Scholarship, 'S' level, taken by only the most able of 'A' level candidates. GCE 'O' level examinations are designed for the most able 20-25% of 16 year old pupils. Standards of grade achievements have for many years been norm-referenced.

2. Boards administering the Certificate of Secondary Education, set up in 1963 to provide examinations at 16 years suitable for secondary modern school pupils. It was assumed that pupils below the fortieth percentile of an overall ability range would not be entered for these examinations. Entry arrangements for CSE are similar to those for GCE, i.e. single subject entry with no age restriction. Grades have usually been obtained by some form of norm-referencing. Grade 1 CSE is equivalent to a 'pass', now Grades A-C at 'O' level.

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* Scotland administers her own education through a system somewhat different to that in England and Wales.

It is the intention of the present government to replace the GCE 'O' level and CSE examinations by a single examination system at 16+. Discussions are currently taking place to bring this about. It is proposed to introduce a degree of criterion referencing to testing.

The organization of the 11-16 curriculum has been greatly influenced by the 16+ examination system. A usual curriculum pattern for comprehensive schools is for a common curriculum to be offered in years 1-3 of the secondary school, with year 3 being regarded as a diagnostic year for both schools and pupils. At some time during this year a decision has to be made on the two year course leading to public examinations for the majority. 'Schools have the responsibility for deciding, in association with pupils and parents, whether or not to enter their pupils for examinations, in which subjects these should be, how many and of which level and style.' (HMI, 1979). A coeducational comprehensive school offers about 37 subjects to fourth and fifth year pupils of which an average child will choose 7 or 8. Schools usually insist on a common core consisting of English language, mathematics and, for more able pupils, a foreign language, frequently French. Other subjects are then grouped and pupils are required to choose one from each group. Many schools insist that at least one science subject is chosen and science may appear as physics, chemistry, biology, human biology, integrated or combined science, environmental science, engineering science or in some other guise. The percentages of boys and girls choosing the most frequently occurring of these are shown in Appendix B, Tables 2 and 3.

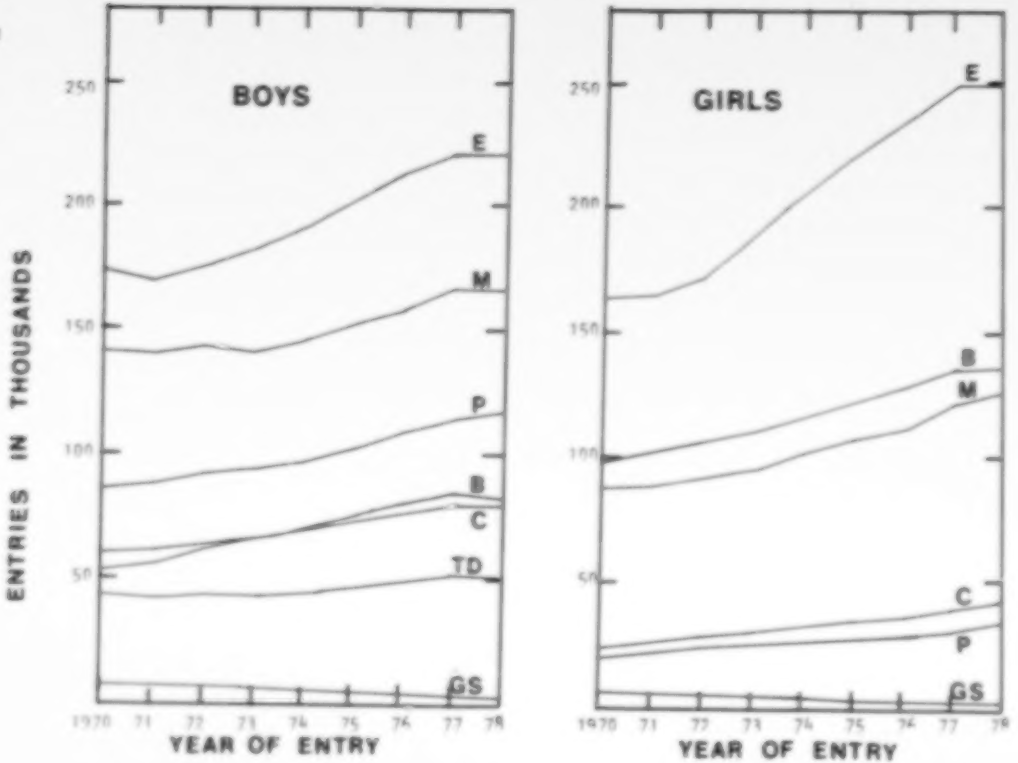
A result of this system and of single subject entry opportunities, is that an individual pupil may enter for some subjects at GCE 'O' level and some at CSE, while others may enter for all 'O' level subjects, others for all CSE subjects and a few (about 20% overall) may not be entered for any public examination.

The trends of entries to selected subjects at GCE 'O' level and CSE examinations during the 1970's are displayed in Figures 1 and 2, following. Marked sex differences can be seen in most subjects.

Appendix A

Figure 1

GCE 'O' LEVEL ENTRIES SUMMER 1970–78



E = English; M = Maths; P = Physics; B = Biology; C = Chemistry; GS = General Science; TD = Technical Drawing.

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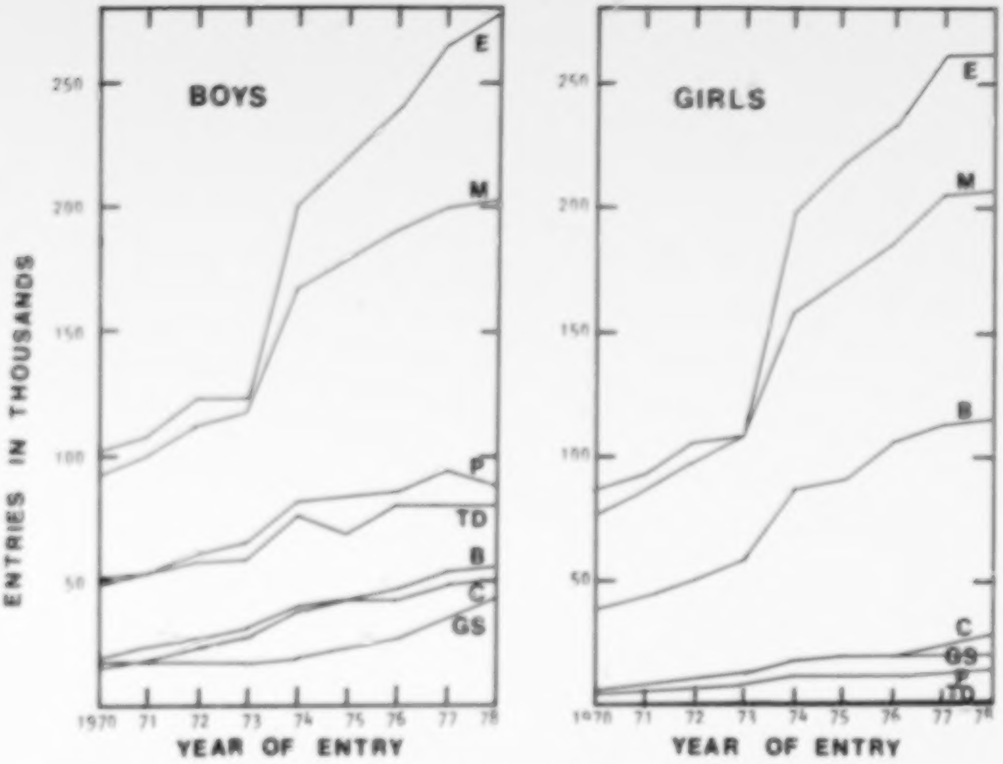
Appendix A

Figure 2

CSE ENTRIES SUMMER 1970–1978



E = English; M = Maths; P = Physics; C = Chemistry; B = Biology; GS = General Science; TD = Technical Drawing.

Appendix B

Table 1. Options in fourth and fifth forms: pupils being offered, choosing and taking particular subjects. Corrected percentages* for comparing segregated and mixed schools.

		Being offered		Choosing		Taking	
		Single sex	Mixed	Single sex	Mixed	Single sex	Mixed
		Per cent of totals of pupils		Per cent of those to whom offered		Per cent of totals of pupils	
		per cent	per cent	per cent	per cent	per cent	per cent
Physics:	Boys	85	91	60	52	51	47
	Girls	62	75	23	15	14	11
Chemistry:	Boys	81	79	36	35	29	28
	Girls	75	78	27	22	20	17
Biology:	Boys	79	91	39	30	31	27
	Girls	96	96	49	53	47	51

* These figures are corrected to compensate for the greater incidence of single-sex schools among grammar schools.

Data extracted from H.M.I. (1975) 'Curricular Differences for Boys and Girls'.

Appendix B

Table 2. Science subjects studied by girls in the fourth and fifth years in single sex and mixed schools: by type of school.

Percentages of girls

	Type of school					
	Mod		Gram		FR Comp	
	Yr 4	Yr 5	Yr 4	Yr 5	Yr 4	Yr 5
Percentage of girls studying						
Physics in						
Girls' schools	-	1	46	32	11	8
Mixed schools	8	5	26	18	13	11
Chemistry in						
Girls' schools	2	2	52	37	21	11
Mixed schools	6	5	39	36	21	19
Biology in						
Girls' schools	38	29	86	79	66	49
Mixed schools	37	37	75	80	51	49
Human Biology in						
Girls' schools	11	17	2	3	7	18
Mixed schools	15	15	10	7	9	9
General or integrated science in						
Girls' schools	19	22	4	4	28	16
Mixed schools	19	16	5	6	15	16
Number of schools						
Girls' schools	16		20		8	
Mixed schools	70		13		144	

Gram. = grammar school

Mod. = secondary modern

FR Comp. = Full range comprehensive

Data extracted from HMI (1979) 'Aspects of Secondary Education in England'

Appendix B

Table 3. Science subjects studied by boys in the fourth and fifth years in single sex and mixed schools: by type of school.

Percentages of boys

	Type of school					
	Mod		Gram		FR Comp	
	Yr 4	Yr 5	Yr 4	Yr 5	Yr 4	Yr 5
Percentages of boys studying						
Physics in						
Boys' schools	51	48	88	80	65	60
Mixed schools	38	37	82	76	49	47
Chemistry in						
Boys' schools	21	23	72	55	48	38
Mixed schools	12	13	66	68	33	32
Biology in						
Boys' schools	22	18	50	48	43	36
Mixed schools	22	17	58	59	28	28
Human Biology in						
Boys' schools	-	-	2	1	6	7
Mixed schools	4	5	1	1	3	3
General or integrated science in						
Boys' schools	27	35	1	1	18	21
Mixed schools	29	27	4	6	21	24
Number of schools						
Boys' schools	11		18		11	
Mixed schools	70		13		144	

Gram. = grammar school

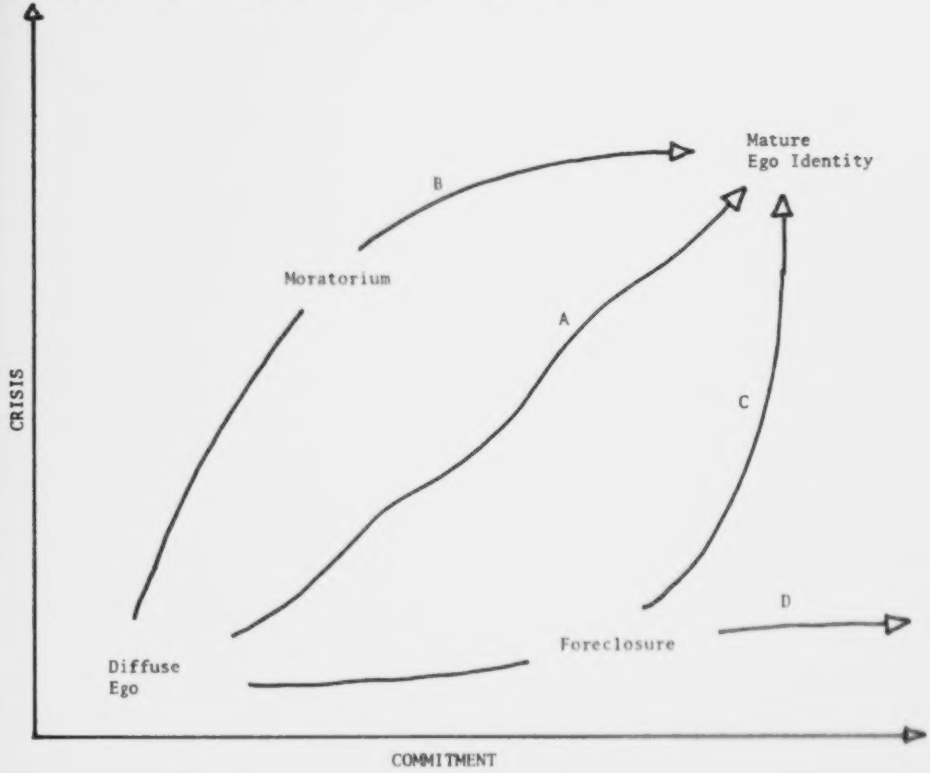
Mod. = secondary modern

FR Comp. = Full range comprehensive

Data extracted from HMI (1979) 'Aspects of Secondary Education in England'

Appendix C

Figure 3. Model of Ego-Identity Achievement for Adolescents



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8. CONSEQUENCES FOR SCIENCE EDUCATION BASED ON THE RESULTS OF GIRLS' LEARNING INTEREST

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Introduction

In the Federal Republic of Germany, as well as in other countries, science and technology are domains predominately reserved for men.

To provide a framework for efforts to reduce girls being disadvantaged in the field of science (especially physics) and technology education and related therewith to achieve the sought for equality of opportunity for girls concerning occupational choice, it seems to me to be useful to consider first of all the current situation of education in the Federal Republic of Germany and to try afterwards to identify sources which may be responsible for this disadvantagement of girls.

By proceeding in this manner there is the possibility to uncover starting points for concrete measures in the field of curriculum development and innovation for achieving the set goals and for becoming aware of the possibly necessary accompanying out-of-school measures.

In the Federal Republic of Germany no curriculum programmes which stress making science and technology more attractive to girls - and in this way reduce girls being disadvantaged in the field of education in science and technology - have been developed or started now. But there have been some investigations done to analyze the differences between boys' and girls' interest in science and discussion of how to make science and technology more attractive to girls increases.

In this paper, findings of these investigations will be dealt with in some detail and analyzed with a view to identifying sources of girls being disadvantaged in the field of science and technology education. Concrete consequences for curriculum structure for science and technology courses will be derived and discussed on the basis of these results.

The Current Situation in the Field of Science Education

The number of higher-level students (11th to 13th grades of the so called 'Gymnasium') who take physics as a high-performance course (five hours per week) or as a basic course (three hours per week) is alarmingly low in several of the states (Länder) of the Federal Republic of Germany[1]. For example, in North Rhine Westfalia the percentage is 25 % in physics which means that 75 % of the higher-level students no longer take physics. In table 1 you can see the distribution of how many higher-level students took basic or high-performance courses in biology, chemistry and physics in the 12th and 13th grades in the first half of the school year in 1979/1980. In summary, the percentage of higher-level students who take basic or high-performance courses is about 81 % in biology, 40 % in chemistry and 33 % in physics. (WELTNER, 1979).

Among higher level students who choose physics as high-performance course the percentage of girls is only about 10 % (EBBINGHAUS, 1977, 477).

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[1] According to an agreement of the Standing Conference of the Ministers of Education from 1972, the upper stage of the "Gymnasium" (grammar or high school, secondary level II) was reorganized during recent years. The central point of the reorganization was the phasing out of the traditional age-group class and the introduction of a course and credit system quite similar to the American model. The realization of this agreement was regulated individually by supplementary agreement in the states of the Federal Republic of Germany. At the upper stage of the "Gymnasium" mathematics continues to be a compulsory subject, at least in a form of a basic course. In the sciences, i.e. biology, chemistry and physics, students are given freedom to choose 'semester courses': at least, such a course has to be chosen.

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Among all students in 13th grade of 'Gymnasium' who intend to continue their studies at the university after their A-level (Abitur) the portion of girls who want to study physics amounts to 6.7 % in 1981 (Bildung im Zahlenspiegel, 1981).

Motives for Deciding Not to Elect Physics at Secondary Level II

The considered results of higher-level students behavior in electing courses in the field of science give rise to the conclusion that the subject physics is relatively unpopular.

Which are the motives for deciding not to take physics as an elective at secondary level II?

This question was investigated among others by BORN and EULER (1978) and MITTELACHER (1979). BORN and EULER report an extensive inquiry of physics teachers, students and beginners at the university. MITTELACHER questioned higher-level students who had not chosen a higher-performance course in physics. However the results are not separated according to girls and boys. Essential motivations for the decision not to elect courses in physics from the students' viewpoint are:

- the difficulty of the subject itself, the proximity of physics to mathematics, the wide range of subject matter, the pressure to perform
- out of fear of getting an unsatisfactory average in the "Abitur-report", easier subjects are chosen[2]
- many students get detered by physics instruction at secondary level I

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[2] At the end of the 13th grade of the Gymnasium students get the certificate "Abitur" (A-level) which makes students eligible for university admission. For certain overcrowded subjects (e.g. medicine) admission is dependent additionally on the joint "Abitur-report", (numerus clausus).

In order to clear up this last point, the following arguments are mentioned:

- at secondary level I the students are too little motivated by their teachers: physics instruction is characterized as being dry, boring and no fun
- the interest of the students are not taken into consideration enough
- lack of relation to application: technological applications are too little dealt with
- the importance of physics for todays' society is not exhibited enough
- if more experiments had been done by students at secondary level I, students at secondary level II would be more interested in taking courses in physics.

On the part of the physics teachers the following motives for not electing courses in physics are mentioned most frequently:

- Physics are too difficult, other subjects are easier
- the students have too little interest, they are in want of necessary knowledge (e.g. mathematics)
- deficiencies of instruction during secondary level I, too few experiments
- lack of teachers, frequent cancellation of lessons in secondary level I
- the importance of physics is not known to the students.

Summing up the comments of the students, the situation can be described as follows:

Students must have already had very bad experiences with formalistic, boring and poor motivating instruction in physics at secondary level I. Initially existing interest in physics has obviously been thoroughly killed. In addition, the goals, the urgency and the importance of physics are conveyed insufficiently during instruction. In school, physics goes over the heads of the students - even of the interested ones. (BORN and EULER, 1978, 76f.).

As one can see, the teachers' and students' estimations of the motives for deciding not to elect courses in physics at secondary level II are congruent only to a certain extent.

Cited by students as one of the main reason for the rejection of, and lack of interest in, physics courses at secondary level II was that the interest of the students were not taken into consideration enough during physics instruction at secondary level I.

Which is the interest in physics and technology of the students at secondary level I and how does this interest change while passing secondary level I? Is the interest in physics of girls similar to or different from that of boys?

These questions were investigated among others by TODT et al. (1974) and WELTNER et al (1979).

TODT et al. analysed the interest of students at secondary level I of German comprehensive schools in the fields of physics and biology.

They developed a two-dimensional interest questionnaire which, firstly, covers the most important teaching subject matter respectively the teaching objectives intended by the skeleton guiding principles for the fields of biology and physics. Secondly, it encompasses student activities which are brought to bear in the courses of biology and physics instruction.

This so-called PIT questionnaire covers a total of 120 items on 5 subject areas each from physics and biology, as well as 12 student activities. The selected subject areas and student activities are provided in table 2 together with the number of items provided per subject area. The items of the questionnaire are constructed in such a way that respectively every subject area is combined with certain activities. Four such item samples can also be found in table 2. Each item was to be assessed on the basis of a five point scale, whereby (1) was very much and (5) very unwillingly. In addition, other inquiry instruments were developed which cannot be dealt with in this paper.

The study was conducted at the beginning of 1974 and involved students of grades 5 through 9 (age range: 10 to 15 years). For the subsequent excerpts from the report on the results, the answers of a total of 5.625 students (2861 boys, 2764 girls) were considered. Among other things, in the course of data analysis variance analyses were used for the subject areas and interest scales.

1) The interest of girls and boys in the individual subject matter and their different extent at grades 5 through 9

The mean values of students' interest scores in the subject areas in the individual grades are presented in Fig. 1. The results show that girls' interest in all the physics subject areas investigated here are considerably lower than those of the boys. Exactly the opposite is true for the biology subject areas. However, the difference of interest in the two subject areas zoology and ecology is not as pronounced. Besides this, there is a significant decrease of interest in most subject areas for girls and boys alike as their age increases. The only exceptions are the two biological subject areas: anthropology and ecology.

A significant decrease of interest in all physics-oriented subject areas begins earlier by girls than by boys: by girls from 6th to 7th grade; boys' interest decreases from 7th to 8th grade.

The picture is not so uniform where biology-oriented interest are concerned. While the interest of girls as a whole in zoology

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and botany decreases, their interest in anthropology and ecology increases.

The change of mean values throughout grades 5 through 9 are statistically significant in all subareas of the subject areas. One exception here is the boys' change of interest in the subareas anthropology and ecology.

The rank positions of the mean values of the interest of girls in the physics-oriented subject areas remains relatively constant. On the first places are magnetism and optics. Then come thermodynamics, mechanics and electricity. As far as the biology-oriented subjects are concerned, the subject area anthropology changes from third place in 5th grade, to second place in 6th and 7th grade, and to first place in 8th and 9th grade. The order of the remaining subject areas is as follows: zoology, botany, ecology. In 9th grade girls' interest ranks higher in ecology than in botany.

2) Boys' and girls' interest in typical activities in the field of natural sciences and their different extent in grades 5 through 9

The mean values of students' interest in the different activities at the individual class levels are presented in fig. 2 - separately for boys and girls.
It can be seen from fig. 2 that the interest of girls in most of these activities in the field of natural science is distinctly lower than that of the boys. Exceptions are the activities: observing, learning, explaining and discussing. Interest in observing is considerably greater for girls than for boys.
By learning and by explaining there are no considerable differences. By discussing, girls' interest at first is lower, in grades 8 and 9 but then increases above that of boys.

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When one observes the course of the mean values of interest in activities throughout all class levels, it becomes clear that interest in these activities in the field of natural sciences decreases for both girls and boys from grades 5 through 9. An exception here for girls is the activity "discussing": girls' interest in discussing increases significantly from grades 5 through 9.

Before possible consequences deriving from these findings are discussed for structuring physics instruction, the results of the investigation conducted by WELTNER et al. (1979) should be discussed briefly.

WELTNER et al. investigated girls' and boys' interest in physics and technology. The study was carried out in the summer of 1977. A total of 1234 students grades 5 to 10 (age range 11-16 years) of all types of schools existing in the Federal Republic of Germany participated in the study.

Beside others the following aspects were investigated:
- girls' and boys' interest in subject matter from physics and technology
- girls' and boys' practical and theoretical orientation in the field of physics and technology and
- girls' and boys' background of experience as well as their spare-time interest in this field.

A general questionnaire containing groups of questions on all these aspects was developed. To illustrate the kind of questions here a brief description of some of them:

From a pool of 34 topics covering the field of mechanics, thermodynamics, optics, electricity and nuclear power plants the students had to choose those topics, which, in their opinion should be included in physics courses. For each topic an example was presented expressing the physics aspect and one example expressing the technological aspect.

To examine the practical and theoretical orientation the students were asked two different things: firstly, to choose up to eight programmes which they would like to watch from a presented list of 16 fictional TV programmes. The formulation of the one half of the programmes was oriented practically, the other half theoretically. Secondly the students hand to choose which of the following four methods of teaching they would like most: reports by students, experiments done by students, lecturing by the teacher or demonstrations of experiments done by teachers.

The findings indicate, that both girls as well as boys are more interested in technological than in physics subject matter. This preference is more pronounced in the case of boys.

Both girls and boys are more interested in practically oriented programmes. As can be seen in table 3 both girls as well as boys prefer practically oriented instruction in physics. As expected, boys' background of experience in the field of physics and technology is greater than the girls' one. Refering to spare-time activities in the field of physics and technology there are significant sex differences. See figure 3. Besides this, there exists a positive and significant correlation between out-of-school activities concerning physics and technology and students' marks in physics, which is particularly pronounced for girls. The correlation is 0.79 for girls and 0.29 for boys. Another interesting finding results from a factor analysis of the chosen subject-matter. Two factors or complexes of interest were obtained for girls and three for boys.

"The *first factor* is equally frequent among boys and girls. It can be described as a *general interest in technical equipment*. It includes topics such as "the camera" or "the calculator" as well as "the clock" or "the telephone".... For girls a *second factor* was obtained "which expresses *general interest in natural phenomena*... it includes natural phenomena known from everyday life (such as high and low tides, the Fata Morgana, echoes etc.)".

For boys a *second factor* was identified which a *general interest in electric phenomena and equipment*, it includes topics like electric current generators, transistors, electromagnetic induction etc.

"The *third dimension* of interest could generally be termed *interest in contemporary problems in physics and technology*. This includes subjects such as nuclear power plants, satellites. radioactivity etc." (WELTNER et al. 1981, 188). A last finding which should be mentioned is, that twenty-three physics teachers, who were asked to predict the interest of their students in the topics mentioned, predicted far more accurately the interest of the boys than the interest of the girls.

Consequences Based on these Findings for the Improvement of Girls' Education in the Field of Science (especially Physics) and Technology

What impulses can be deduced from the findings presented to improve the education of girls in the field of physics and technology?

As far as science instruction at primary school (1st to 4th grade) is considered girls' and boys' interest is equal and relatively high (KAISER & MÜSGENS, 1979).

Already within the first year of secondary level I girls' interest in science decreases refering to the boys' interest.

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A strong falling off girls' interest, especially in physics, could be observed from the 5th to the 6th grade. That means, if the initial girls' interest in science ought to be preserved and supported measures for innovation of science education have to begin accordingly already at the first grade of secondary level I.

Doesn't one succeed in motivating girls at secondary level one e.g. in physics and technology probably girls will not elect high-performanced or basic courses in physics at secondary level II. With that, the chance of the school to enable for girls an access to physics and technology has given away far extending.

It would be too hasty to assume one has nothing but to consider the girls' interest in certain subject areas and activities in science instruction and than the problem of girls being disadvantaged in the field of science and technology education would be eliminated. The interest of girls represents only one point among others were innovation necessarily has to take place. The problem has to be considered in an extensive frame and efforts to solve the problem have to be attempted from different points. For example the findings of the described investigations of higher-level students' behavior in electing courses as well as of the change of interest during secondary level I point to the fact that science instruction (especially in physics) as it is performed at the schools in the Federal Republic of Germany today needs innovation not only for girls but also for boys.
Within the frame of such an innovation the girls' interest science represents one aspect among others, which has to be considered. If one tries to identify the differences between science instruction at primary level and at secondary level I in order to get an explanation for the falling off interest already at the beginning of secondary level I it is to observe that science instruction at primary level is relatively oriented at the experienced world and environments of the children. But

the very lack of relation of real life at secondary level I is stated by students as a substantial reason for unpopularity of physics.

The general expressed valuations and wishes about the methods of instruction and innovation of the physics instruction girls and boys are very similar. (GÖTTSCHING 1975; WELTNER et al. 1979). If one takes into consideration the interest against certain subject matters and specific activities as well as the real behaviour of the girls electing basic and higher level courses at secondary level I and corresponding the election of the faculty there are clearly differences remarkable (TODT et al. ,1974 ; Bildung im Zahlenspiegel, 1981). This disagreement authorizes assumption that sources of disadvantagement of girls in the field of science and technological education are to be found in other areas, too and corresponding to that processes of changing will have to be put up there. This point needs a dicussion in detail, however, it is not possible to do it within the extend of this paper.But some of those areas should be shortly mentioned where efforts for innovation will have to be put up parallel.

Such an area represents the role identification of girls as it is impressed, lead and on many fields promoted by our society. Examples therefore are: In schoolbooks offerd female models for identification (Bittmann,1978;1980; Nave-Herz, 1978); the retained prejudice of a wide portion of the population,of scientists, but as well of some physics teachers, that girls "by nature" are less gifted and less motivated in science in general and particularely in physics and technology (Pygmaleon effect,ROSENTHAL, 1968), as well as the representation of science and technology as characteristically male and connected with that a far-reaching reservation corresponding areas of occupation more or less exclusively for men. That here the public media could contribute effectivily to change traditional and stabilized structures demonstrates among others KROPIONIGG (1979).

After this short outlining of the frame where in my opinion processes of change have to be put up, in so far one takes seriously the intention to reduce the disadvantagement of girls in science education and of opportunity concerning occupational choice. Now to the inpulses for curriculum structure for science and technology courses which can be derived from the available findings:

To motivate girls, and in wide areas the boys, too, for a better engagement in.physics and technology by instruction.at secondary level I it would be necessary to make aware and to demonstrate the relation of physics to work-a-day world and importance of physics for our society. That means, technical application and physical problems of work-a-day world should be subject of physic instruction, too.

The close connection between technical/ scientific and social/ economic developments should be subject of physics instruction. - Experiences by testing certain IPN-curricula allow the assumption that in this way the engagement of girls in physics instruction can be promoted.-

Taking up and explaining natural phenomina in science instruction would encounter girls'interest and probably highten there interest for subject areas.

Following TODT et al. (1974) among others the need for cooperation increases by girls from the 5th to the 6th grade. Frequent practicing of experiments done by students and working in small groups would be therefore useful, too for the engagement of girls with the subjects of physics instruction.

By offering adequate models for identification,e. g. women employed in scientific occupations, women applicating physics knowledge in their spare-time respectively in their work-a-day world could contribute to modify role perception of a wide portion of girls.

To give the girls a survey about opportunities and applications of physical and technical knowledge, informations of corresponding occupations and fields where scientific and technical knowledge is applicated, and to which science education is a condition, it should be subject of instruction.

The mentioned suggestions are of general character and they are not very new. They have been applicated and they are applicated more or less unsystematically in traditional physics instructions.

In how far they are effective to reduce the disadvantagement of girls in the field of science and technological education, can only prove their consistent realization and testing in concrete instruction.

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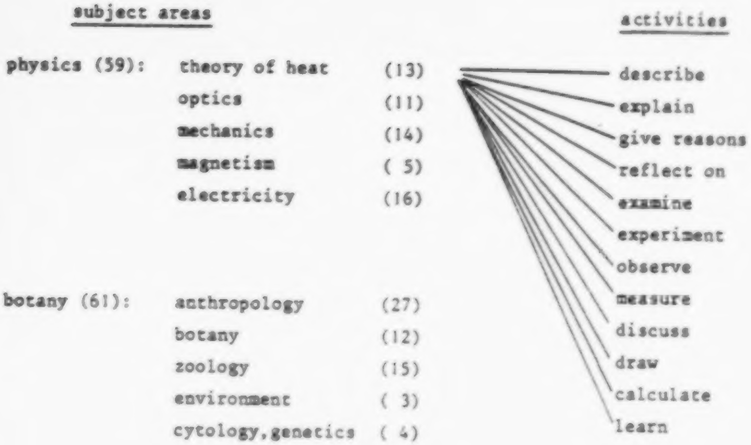
table 1: Frequency of electing basic (BC) and high-performance courses (HPC) in science e.g. biology, chemistry, and physics at the 12th and 13th grade of the first half of the school year in 1979/1980 (in per cent).

	biology			chemistry			physics		
	HPC	BC	together	HPC	BC	together	HPC	BC	together
Baden-Wurtemberg	31,4	40,5	71,9	11,2	30,2	41,4	17,8	17,0	34,8
Bavaria	12,7	63,4	76,1	7,7	31,1	38,8	14,4	23,2	37,6
Bremen	31,8	35,5	67,3	9,6	20,6	30,2	13,4	15,3	28,7
Hamburg	43,8	32,6	76,4	13,0	26,6	39,6	12,8	16,0	28,8
Hesse	38,9	45,4	84,3	12,9	43,0	55,9	12,1	27,0	39,1
Lower Saxony	35,8	37,8	73,6	11,9	16,6	28,5	12,8	12,3	25,1
North Rhine Westfalia	33,8	40,5	74,3	5,9	17,4	23,3	8,2	14,6	22,8
Rhineland Palatinate	46,1	33,2	79,3	16,1	33,1	49,2	16,7	19,0	35,7
Saarland	43,1	27,3	70,4	19,6	18,0	37,6	14,0	12,6	26,6
Schleswig-Holstein	32,3	45,3	77,6	8,3	32,4	40,7	13,3	14,8	28,1
Berlin	39,9	41,2	81,1	12,2	34,1	46,3	11,5	25,2	36,7

taken from: WILLENBACHER, 1981, 56.

Tabel 2: Structure of the questionnaire "preferences of contents and activities" (PIT)

(in patantheses the number of items is given; the total number of items n = 120)



subject areas			activities
physics (59):	theory of heat	(13)	describe
	optics	(11)	explain
	mechanics	(14)	give reasons
	magnetism	(5)	reflect on
	electricity	(16)	examine
			experiment
			observe
botany (61):	anthropology	(27)	measure
	botany	(12)	discuss
	zoology	(15)	draw
	environment	(3)	calculate
	cytology, genetics	(4)	learn

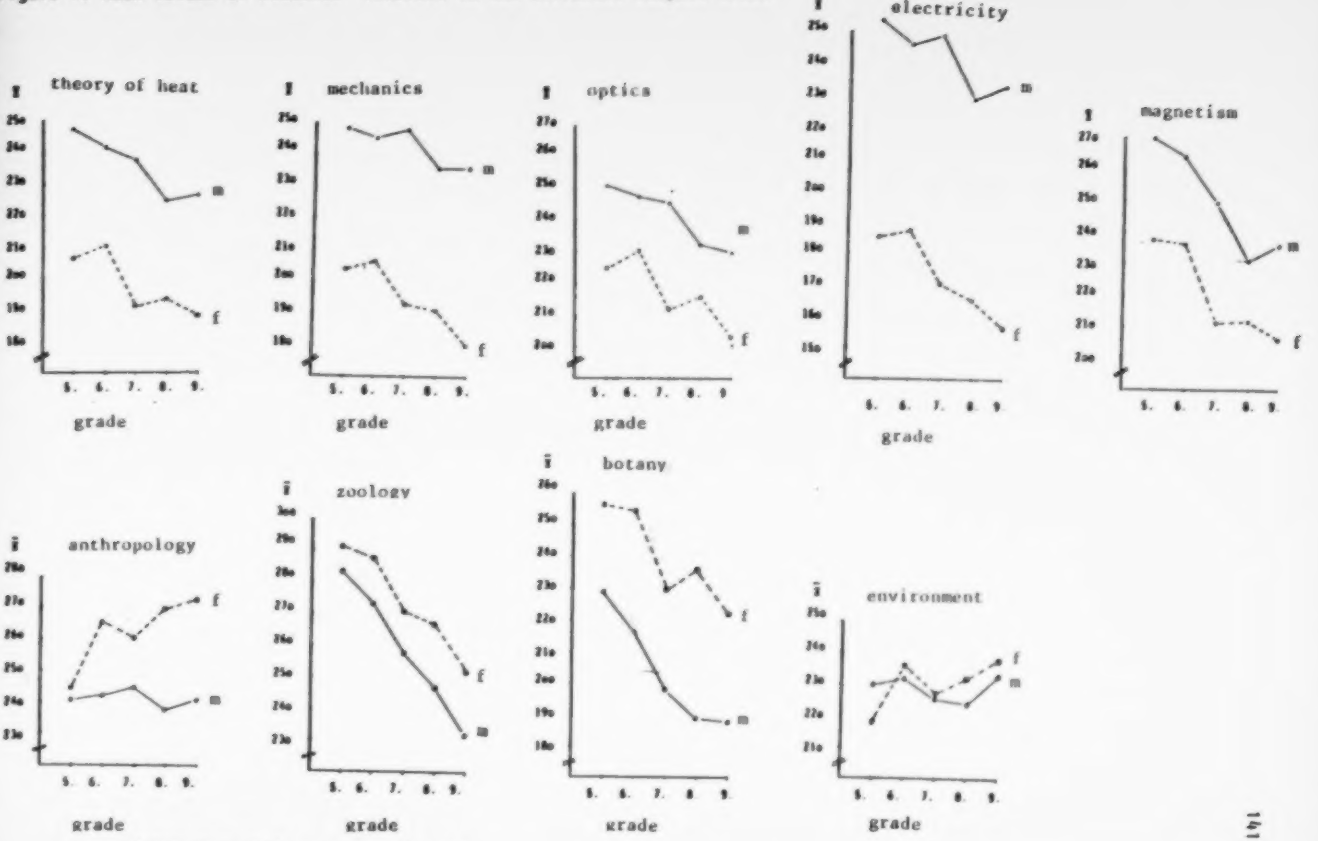
in the same way as for "theory of heat" the other subject matters are combined with the activities

taken from TODT et al. 1974, 12

A few examples for items:

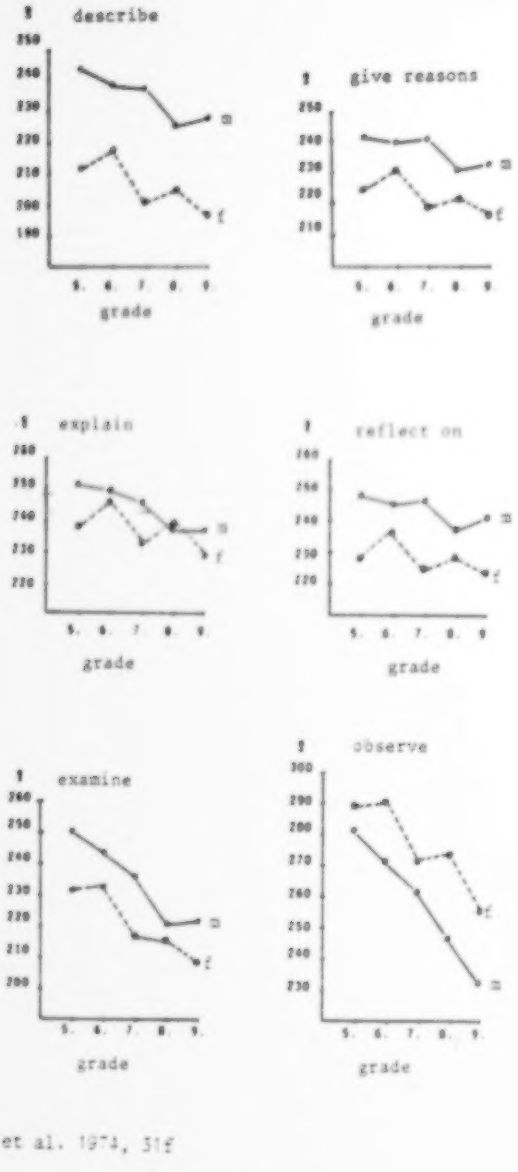
- To make a schematic drawing of the construction of a cell
- To discuss what influence the invention of the steam engine to technical development has had
- to give reasons for the fact that during summertime the interior from a dark car is much hotter than from a brigt one
- To learn what a light year is

Figure 1. Mean values of students' interest in the different subject areas



taken from Todt et al. 1974, 19f

Figure 2: Mean values of students' interest in different activities of science



taken from Todt et al. 1974, 31f

Continuation of figure 2

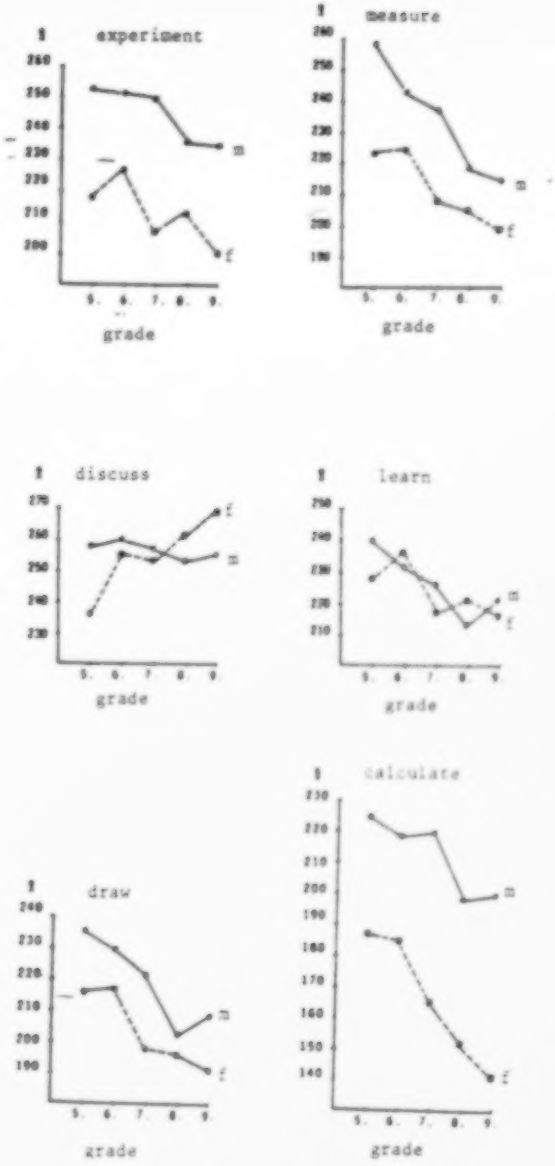
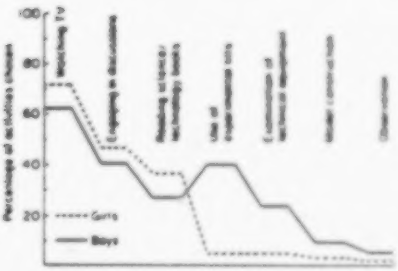


Table 3: Student preference for different methods of teaching

Feature in lesson	Total sample	Boys	Girls	Residence Urban	Residence Rural
Theoretical work done by the students	11%	9%	13%	4%	6%
Experiments done by the students	71%	72%	69%	66%	78%
Lecturing by the teacher	1%	1%	1%	2%	0%
Demonstrations of experiments done by the teacher	14%	14%	15%	24%	10%
No answer	3%	4%	2%	4%	6%

taken from WELTNER et al., 1980, 186.

Figure 3: Students' science and technology activities carried out in their spare time



taken from WELTNER et al. 1980, 188.

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9. A DESCRIPTION OF THE SCIENCE CAREER WORKSHOP PROJECT FOR WOMEN IN SCIENCE

That women are under-represented and under-employed in math/science-related occupations is well documented. Women currently comprise over 40% of the work force in the United States and yet no more than 15% of the Country's scientists and fewer than 3% of it's engineers are women. The percentages of women in other math/science-related areas are similarly low relative to their proportion in the labor force. Recognizing this problem, and the need both to offer encouragement to women entering into mathematics and science-related fields of study, and the need to recruit more women into those fields, Orange Coast College in Costa Mesa, California (USA), submitted a proposal to the National Science Foundation in the Spring of 1981, outlining and seeking financial support for, a program that involved faculty felt would produce that end result. The proposal was one of two submitted by community (junior) colleges nationally that was selected for funding, and one of only 34 from among all colleges that received support. This paper will describe the College, and project as it was proposed and as it is currently being developed.

Orange Coast College is one of the largest community colleges in the United States, with a current enrollment of some 33,000 students, slightly more than 50% of which are female. The College provides programs of study in some 70 technical areas and offers a full range of studies for those transferring on to four-year colleges and universities. It is located on a 200 acre campus just a few miles from the Pacific Ocean in the city of Costa Mesa, California, in the midst of the rapidly growing, highly technical, and largely science/math-related, industrial area of Orange County, California.

Orange Coast College is planning a one-day career workshop for Women in Science which it will conduct in February of 1982. An advisory panel of women scientists and engineers from the local area, as well as others from the College, are in the process of determing the nature of the sessions and identifying presentors and panelists. Preliminary plans call for panel presentations and discussions in all the science/math-related areas, with panelists being women prepared and employed in science/math-related fields, and special presentations dealing with such things as math anxiety, math/science careers and traditional values, career outlook for women, career search techniques, presentation of self, assertion, and other topics of particular interest to women contemplating non-traditional programs and employment. The workshop will include opening and closing addresses by women in science who have been recognized for their achievements, for the image they project to other women, for their personal qualities, and for their ability to inspire. Ample opportunity will be provided by breaks and a catered luncheon, for interaction between participants and presentors. Participants will have an opportunity to evaluate the day's activities, as well as the presentors, in the closing session. The workshop will be publicized both on and off Campus through brochures, news releases, announcements in math/science classes, through the women's center, posters, and in any other way that has potential for attracting women to the program. Channel 50, the District owned television station, will cooperate fully in the effort to apprise women of this opportunity.

The most unique feature of the program being developed at Orange Coast College is not the workshop itself but the continuing activity planned as a follow-up to the Women in Science workshop. The activity is called "Shadowing" and is being designed to bring women students in math/science-related majors into contact with women employed in these areas - women who have completed similar programs and who have degrees in the area of the student's major. Evidence suggests that more often than not the college woman majoring in mathematics and/or the sciences knows no other woman personally, if at all, that is employed in the area of her major. She consequently has no role model to look to and to model after. The shadowing program will attempt to correct this deficiency by identifying women scientists and engineers who will serve in this capacity, as role models, for these young women, and will spend time with them and give them a chance to relate to a woman employed in the occupational areas they have chosen. It is believed that the opportunity to observe women in the field, and to interact with them, will not only positively effect the women students themselves but will have a ripple effect in terms of other women they know.

Orange County, California, has perhaps the greatest concentration of high technology industry of any county in the United States, and among the thousands of scientists and engineers employed by these concerns are significant numbers of women. While these women are not normally visible to student populations they are nevertheless available to them. Preliminary work has suggested that these professionals are in fact eager to provide information to and to interact with students.

In the summer of 1980, Orange Coast College, with assistance from the National Alliance for Business, sent letters to affirmative action officers in approximately 1,000 business and industrial concerns in the greater Orange County area. The letter was designed to determine the number of women employed in professional level math/science-related occupations in these companies, and after describing the "shadowing" concept, sought to determine both whether women employees would be interested in participating in "shadowing" and whether the company would permit their involvement. The response has been most gratifying, suggesting to us that there are both large numbers of women scientists and engineers willing to give time to math/science-interested students and companies that are willing to make it possible for them to do so.

The shadowing activity will be organized around a cross-referenced guide, developed with the funding available through the National Science Foundation, which will contain the names, brief biographies, and position descriptions of women scientists and engineers participating in the program. Possibilities for arranging to spend time on the job with these women will be advertised to students through math/science classes, through the counseling service, and in other appropriate ways. To prevent any possible abuse to the program contact between student and professional would be coordinated through the project director. Students would not have direct access to the women involved until after the initial contact had been made by the director. After this contact the student would then make the arrangements for spending time on the job directly with the woman scientist or engineer involved. The length of time would depend on the circumstances and might vary from perhaps a day to several days of weeks, based upon what the employee and student can work out and upon the relationship they develop. We would expect some to continue over a fairly long period of time.

With industrial concerns like Fluor, Beckman, Rockwell, Aerojet General, Chevron Research, Hunt-Wesson Foods, TRW, Union Oil, a variety of medical and pharmaceutical companies, and many others in the area, and in view of the response to our initial letter, it is anticipated that we could begin the "shadowing" program with a listing of at least 100 to 150 women scientists and engineers. We believe that number could easily be increased to 200 or 300, with every specialty in the math/science areas represented, within a very short time.

The "shadowing" activity will continue over an 18 month period following the date of the workshop, and upon its completion - and during its progress actually, will be thoroughly evaluated. It is anticipated that evaluations will confirm the programs worth and that it will be continued until such time as it is no longer necessary, because of equality of opportunity, to provide such programs. Until that time we believe this kind of approach will produce increased numbers of women in science/math-related fields, and thereby move us closer to that time when equality is an actuality.

10. GIRLS AND PHYSICS TEXTBOOKS IN THE HANDROVER-PROJECT

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The underrepresentation of women in science and technology isn't an isolated problem, it is part of the general problem of "women and education". What is felt as a problem is the fact that in all Western countries there is a difference in the educational career of girls and boys and that the difference turns out to be a disadvantage for the girls .

A description of the entire Dutch situation is impossible to give in this context. But some facts may be useful.

At first a very rough outlook of the Dutch educational structure.

From 6 to 12 years of age:primary education. Same instruction (apart from special education) for all children. Coeducation and coinstruction in all the schools.

There may still be schools with seperate lessons in crafts or needlework, but their number is decreasing.

The same accounts for physical education.

From 12 years on: a rather complex system of secondary education. The main feature is that general education and vocational education take place in separate schools. There is no integrated or comprehensive system in secondary education yet, but political consensus on its desirability is growing.

General education has three types of schools:four years, five years and six years. The six years-school is the pre-university school.

Vocational education at the first level takes four years.

There are schools for technical education, domestic education, agricultural education, economic and administrative education, commercial and nautical education.

Mostly in separate schools, but there is a tendency towards integration. That means: no longer separate schools for technical and domestic education, but one school for vocational education.

All schools are open to both sexes, but in practice almost the entire population of schools for domestic education is female, the population of the technical schools is male.

In general education there is coinstruction in all subjects, except for physical education.

This brief information helps to understand better the following facts:

Girls who at an age of 16 years leave domestic education (4 years) with a certificate are registered as "unskilled workers".

Boys who at the same age leave technical education (4 years) with a certificate are registered as "skilled workers".

Schooling is compulsory until the age of 16. In all types of schools girls after sixteen drop out in a higher percentage than boys.

Girls and boys enter general education in equal percentages.

The number of girls decreases as the level of schooling raises.

In general education, boys choose the math and science subjects, girls take the languages. By this boys have more chances in choosing continuing studies or jobs.

These are only some examples. They could be completed by facts about primary education or higher education.

But the trend is clear and resembles those in the other Western countries, apart from some details resulting from the special Dutch situation.

To resume: the system turns out to offer girls less educational opportunities and hence less career possibilities.

We won't deal with the historical, economic and social causes, but rather look at possible measures to reduce the differences.

> Of course, prior analysis of the historical causes is necessary, as well as the formulation of the ultimate goal. This decides on the nature of the policy measures to be taken.
>
> Our philosophy is, in brief: education must prepare girls and boys for an adult life in which both fulfil professional and domestic activities.
>
> Girls and boys must be able to make free choices.
>
> Education must try to eliminate as much as possible the factor "sex" as a restrictive factor for that choice.

Improvements in the educational structure can be made at different levels: school structure, teacher training, curriculum and textbooks.

It is difficult to decide where priorities have to be laid. At all levels research has to be done and action must be taken.

The HANDROVER- project looks at the textbooks in order to find out if they form a negative factor for girls and to see how they can be improved. The origin of the project lays in an

initiative of the Dutch minister of education. He published in the summer of 1979, together with the state secretary for emancipation, a "Sketch of a policy for emancipation in education and research", in which several measures were announced to promote educational opportunities for girls.
One of them concerned textbooks. It was written:

> "By their choice of subjects, by the roles men and women, girls and boys play in them, by the illustrations they contain, by implicit judgments, textbooks can, on purpose or not, strengthen or combat sex role conceptions. It is of extreme importance to be conscious of this by choosing teaching materials or by producing new ones. The Advisory Group for teaching materials has been requested to construct guidelines which can be used by teachers to test aspects concerning emancipation in teaching materials and which authors and editors of textbooks can apply in writing and illustrating new material or in preparing reprints."

The HANDROVER- project started in order to construct those guidelines.

> The word HANDROVER contains the elements of the project : a manual for the changing division of roles of men and women.

Why textbook analysis

Textbook analysis is a frequently used instrument, especially in investigations concerning sexism in education.
Many people however think it is the least urgent thing to do, since a "good" teacher can use a "bad" book, just to make pupils aware of the sex bias. Yet there are reasons to look at the textbook:

- Even if there is a tendency among some teachers to make their own materials, textbooks are used in regular instruction on the average for 80% of the time.
- Dutch research points out that awareness of sex bias among teachers is still rather scarce. Many teachers won't be able or won't feel the need to correct textbooks.
- Reducing sexism in textbooks doesn't only mean correcting the existing text, but making new ones. This requires rather specialised knowledge about women's issues and can't be asked of every teacher.

What makes textbook analysis problematic is the fact that, despite several hundred years of use, we still don't know their impact. There are many factors influencing the pupils and it is almost impossible to isolate the factor "textbook". Our point of view is that it isn't possible to establish a hierarchy of actions that should be undertaken prior to others. Work has to be done at several levels and textbook analysis is one of them. Yet projects must not run in isolation. Since textbooks are the vehicles of the content of education, collaboration with curriculum projects is desirable. In the Dutch context, an effort will be made to have the physics-part of the HANDROVER- project join the MENT-project(curriculum development for girls in science and technology).

But the HANDROVER-project itself has a broader scope. The original assignment wasn't very specific. Thus, some choices had to be made to delimit the project. The first choice was to work on textbooks for primary education and for secondary general education, leaving the vocational education apart, since textbooks for this type of education introduce a whole range of new problems.

The second choice was to do some case studies, since it is impossible to work on all subjects. This choice resulted from our hypothesis that it wouldn't be possible to construct one type of guideline for all kinds of subjects at all levels.

Problems for girls are different in the various subjects, causes may vary, so possible solutions may vary too.

In order to verify this hypothesis, case studies were undertaken in three different fields: languages- social sciences- natural sciences.

For the languages "mothertongue", so Dutch language, was chosen. Since mothertongue is a compulsory subject in all the schools, there are no differences in choice between girls and boys. (For modern foreign languages, the situation is different. Here we see more girls than boys, especialy in French and German, English being chosen by almost all pupils).

There are several elements in language books which can be analysed
The first element is the content of instruction : the theory of grammar, the theory and history of literature.
We will not deal with the grammar, considering it as a system of rules which should be studied as such.
In literature, more attention can be given to the literary products of women. Also to the question whether there is a specific'female writing'.
The second element is the language as an illustration of the theory. Especially language books contain many stories, and there are separate readers too, in order to confront pupils with literary products or simply to learn them read and write.
Most of the existing textbook analyses have been dealing with language books. They are unanimous in their judgment concerning the sex-stereotyping of the texts. The findings are so well known that they will not be repeated here.
The third element is not really an element proper to language books. It applies to all books, but can best be analysed in this context. It is the problem of the language as a vehicle of the content of instruction. All the textbooks use language, historical knowledge is communicated by means of language, mathematical knowledge as well, and so on.
So analyses concerning this third element will not only apply to language books, but to all other subjects.

For the social sciences a case study has been made on history.
More girls choose history in secondary education. At the university level they only form about 30% of the students.
But participation is not the biggest problem. What strikes most in history textbooks is the almost complete absence of women, despite the fact that in early centuries too women formed 50% of the population.One of the causes must be found in the accents historians have put until now: much attention to political events, military events, less attention to social events and family life.
Girls follow history lessons in quite big numbers, but they are not finding their own past. What must be done is change the content of the history books, in order to include women's history.
This gives methodological problems, since many sources in women's history have disappeared or are biased, but at least we know what we are looking for.

The third part of the study brings us to the topic of the GASAT-conference: out of the natural sciences a case study was made on physics.
Far more boys than girls choose science subjects; among these subjects, physics is in the most unfavourable position.
The rank order of girls'choices is : biology- chemistry- physics. Which mecanisms work at the disadvantage of girls?
There are many and they are intertwined. In the professional world, girls don't see many women working in scientific or technical careers.They lack models, they lack career perspectives.
Are women not working in those fields because they are incapable of handling technics? Many people do believe so.
Teachers may share that belief as do the pupils.

As to the curriculum: do girls underachieve only because society does not expect them to be good at science and technology, or is it also because the curriculum doesn't meet the interests of girls.

Interests of girls are often mentioned as a topic. Yet, nobody knows for sure what "the" interests of girls are. Do all girls have the same interests? The danger is that by caring for girls'interests we reintroduce sex-stereotyping.

For example by thinking that girls'needs are met when all the examples in the textbooks deal with sewing machines, cooking ranges and child care.
There are some indications however. More illustrations on human activities and less abstract texts.
More information about what science means for society, about the danger but also about the good things (see for example Ormerod, 1979).
In the average physics textbook women are scarcely mentioned and if they are,they are represented in traditional female occupations or attitudes and not in scientific activities.
No thorough analysis has been made, but British observations (Taylor, 1979) coincide with the Dutch situation.
It is frequently said that textbooks should gain by including more practical life situations. Mathieu Dumont (Eindhoven University of Technology, unpublished report) looked at the present structure of some Dutch physics textbooks. He found very

Towards guidelines

In the actual state of the research it is rather difficult to give guidelines for new physics textbooks. Some more curriculum experiments should take place in order to see if they are in any way effective in bringing girls to a more positive attitude towards physics.

Yet an attempt is made.

As mentioned earlier, guidelines can be divided in:

general guidelines concerning illustrations and text;
specific guidelines concerning the physics content.

On the basis of a number of hypotheses and an analytical scheme, the following guidelines could be formulated. The first two guidelines are concerned with quantity, the following three with quality and deal with activities, qualities and attitudes.

Illustrations

1. Illustrations must show persons, not only abstract images.
2. Illustrations must show women and men in equal numbers, individually or in groups.
3. Illustrations must show both women and men in professional situations and in private, domestic, stituations in an equal repartition.
4. Illustrations must not systematically depict women and men with the qualities that are traditionally ascribed to one sex (e.g. women nurturing, passive, men adventurous, active).
5. Illustrations must not depict persons exclusively or by preference in sex specific attitudes, e.g. men in dominant positions, women in subordinate positions.

Text

For the text, qualitative statements are important. Yet there is a close connection between quantity and quality, for as we have seen in the example of history, absence of women (a quantitative fact) may lead to distortion of history (a qualitative fact). So with some variation, the recommendations for the illustrations can be applied.

1. The text must not only deal with abstract facts or theories, but must show the relationship with the interests of human persons.
2. The text must deal with women and men in equal percentages.
3. The text must represent both women and men in professional situations and in private, domestic situations in an equal repartition.
4. The text must not systematically represent women and men with the qualities that are traditionally ascribed to one sex (e.g. women nurturing, passive, men adventurous, active).
5. The text must not show persons exclusively or by preference in sex specific attitudes, e.g. men in dominant positions, women in subordinate positions.
6. The language used in the text must not suggest that women are excluded.
7. The language used in the text must not speak of women in a negative way: demeaning, ridiculing, childish.

The physics content

1. Physics textbooks must not only deal with abstract theories, models or facts, but must show the relationship with the interests of human persons. *
2. Physics textbooks must show the (positive) social implications of science.
3. Physics textbooks must take examples not only from the professional world but from daily life too.
4. Physics textbooks must represent women in professional scientific positions too.

* This is the first recommendation for the "text", but is repeated here because of its great importance for physics.

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11. CAREER AND GOAL PLANNING FOR GIRLS ENTERING THE SCIENCES AND TECHNOLOGY

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I. INTRODUCTION

Due to imposition of sex roles on children at an early age, girls must be technically and motivationally superior to boys in science and technology to attain even average career goals. To determine a solution enabling girls at the secondary level to have the same opportunities and accomplishments as boys, career and goal planning based on game theory principles is proposed. These principles allow the instillment of the committment required for girls to overcome the sexual stereotypes imposed by society. This basic tool for strategic career goal planning allows girls an understanding of the meaning of an increased interest in science and technology and the methodology to attain the same achievements and opportunities as boys. The introduction of game theory to girls should be made both in the textbooks, i.e. illustrations and statements, and by parents, educators, and the media. The analogy of the theory of Two Person Zero Sum Games is described in terms of day-to-day experiences of girls in the classroom, at home, and in public places. An understanding of the control that girls can exert during a game situation enabling the maximum payoff, will be useful in: (1) selecting the science or technology career at the secondary level, and (2) carrying out the course work and political maneuvers required for success in attaining the advanced science and technology degrees.

II. PROBLEM STATEMENT: BEHAVIORAL DIFFERENCES BETWEEN BOYS AND GIRLS

From the time that girls and boys are born, society separates and classifies them based on their physical sexual attributes alone. The corresponding behavioral responses by girls and boys during the ensuing years can be studied with game-theoretic analysis to determine the base line of rationality for these responses[16]. The link between game theory and this behavior with respect to science and technology will be examined here. The following training given to boys but deleted for girls in most cases strongly impacts their attainment of careers in science and technology[9]:

(1) basic skills and motivation for learning how things work by assembling and disassembling them;

(2) excelling at games;

(3) independence;

(4) reward for deflecting aggression away from them and into useful paths;

(5) mastering their own environment;

(6) visualization of themselves as strong, powerful, or dominant;

(7) overestimation of their own positions in a "toughness hierarchy"[9];

(8) understanding of competence as objective achievement, success at what they do, and emergence as a leader;

(9) belief in their own ability to control their fate or determine outcomes of sequences of events in which they participate;

(10) visualization of risk as a consequence of judgment based on experience;

(11) removal of fear as a first emotional reaction to early attempts at evaluation of possible outcomes;

(12) seeking a group identity;

(13) assertiveness.

Traditional ideas about femininity conflict directly with achievement. This is inherent in the skills training of girls connected with housekeeping, rearing children, and sustenance of a marriage relationship. This training has no merit in the competitive arena of the world of science and technology. These skills, when thoroughly ingrained in girls during the formative years, tend to prevent completion of successful career goal steps. This negative societal training enforces deep committment to family responsibilities as opposed to enforcing the compatibility[9,13] of committment to a balance of career and family responsibilities. Training of the effective use of game theory skills will result in the removal of the negative influences retarding the girl's progress because of her lack of training of traits (1) to (13) above. The introduction of the game theory in textbooks, the media, and by parents and educators will teach girls and boys as equals and identify factors required for successful completion of projects as opposed to the negativism of sexual role responsibilities.

III. GAME THEORY ANALOGIES[5,6,7,11]

This section deals with analogizing the traits required for equal success and opportunity for science and technology for girls to the theory of games[14,16,20,21]. In a game, the following three observations are first given for each individual: (a) certain choices available, (b) knowledge of the consequences of these choices for each choice of opponent, and (c) choice must be made independent of knowledge of the opponent's decision. The type of game most commonly occurring in the day-to-day lives of girls is a Two Person Zero Sum Game[14]. The Two Person Game definition concerning science and technology motivation and career goal growth for girls indicates that the two players are the girl and either a superior (i.e., a parent or educator) or a classmate. Zero Sum means that the gain of one player is matched by the loss of the other player. There is then a single payoff function, because of only one strategy for each player. Formally[14], we define the game as:

$$\Gamma = (S,T,P)$$

where,

S, T = pure strategies for each player, the girl and her opponent, respectively;

P = payoff function;

$P(s,t)$ = gain for girl when she uses strategy s and her opponent uses strategy t ($s \in S$, $t \in T$).

Then, because of the Zero Sum definition,

$p(s,t) < 0$ gain (girl loses),

$-p(s,t)$ = gain or loss to her opponent.

The use of a mixed or optimal strategy could also be useful for a more exacting development of traits (1) to (12) if the single payoff function did not yield the expected results. Trait (13) would then enforce the development of how each pure strategy could be optimally used. The further formalism[14] for mixed strategies redefines the following parameters:

S = girl's m pure strategies = probability vector

$\sigma(S) \ni \exists, \sigma(s_1),\ldots,\sigma(s_m);$

T = opponent's n pure strategies = probability vector

$\tau(T) \ni \exists, \tau(t_1),\ldots,\tau(t_n);$

$$p(\sigma,\tau) = \sum_{s \in S} \sum_{t \in T} \sigma(s)\tau(t)p(s,t);$$

Game Solution = (σ_0, τ_0, v) for mixed strategies σ_0 and τ_0
$\ni v = p(\sigma_0, \tau_0)$, $p(\sigma_0, \tau) \geq p(\sigma_0, \tau_0) \geq p(\sigma, \tau_0)$
for all $\sigma \in S$, $\tau \in T$.

The most optimal plan of action for each of the two players is naturally to try to maximize their respective payoff functions. Since the Zero Sum Game is assumed, let us determine the most positive outcome for the girl formally with the following steps[3,4,14]:

(1) The girl's opponent tries to minimize her average gain. Now for this science and technology problem or career goal decision, the girl is assured of $\min_{t \in T} p(s,t)$.

(2) The girl's choice of action must be made such that her payoff will be at least $\max_{s \in S} \min_{t \in T} p(s,t)$

(3) The payoff to the opponent is the negative of the girl's payoff, so for any pure strategy t that the opponent chooses,

$$\min_{s \in S} (-p(s,t)) = -\max_{s \in S} p(s,t)$$

(4) The girl can then obtain a payoff of at least $\max_{s \in S} \min_{t \in T} p(s,t)$ or no more than $\min_{t \in T} \max_{s \in S} p(s,t)$, where

$$\max_{s \in S} \min_{t \in T} p(s,t) \leq \min_{t \in T} \max_{s \in S} p(s,t).$$

The modeling of the girl's experiences by the game theory formulation will enable girls to see risk in science and technology issues as a consequence of judgment based on experience rather than as an issue composed of a maximum certainty of personal loss. An N-Person Game[16] model is also possible for the girl in reference to science and technology problems, if there are multiple superiors or classmates. However, from the basic Two Person Zero Sum model the baseline for the majority of situations has been provided.

IV. SOLUTION METHODOLOGY

The solution model proposed in section III must be executed for girls by parents, textbook writers, the media, and educators. An example in the home is for the father to train the girl that risk means either an opportunity or a cost, a gain or a loss, injury or growth. This encourages the girl to use her mind to realize that she has control of most situations; i.e., she can ensure her success in most situations by assertiveness as opposed to passiveness, which will surely ensure her failure. The father is referenced here because the mother in the majority of homes will not have the training of traits (1) to (13) in her background. The textbook writers, media, and educators have a lasting impression on girls with written and verbal communication. As a result of the observations of Jacklin and Mischel[9] in a study of elementary school textbooks, good things should be illustrated as happening both to the girl and the boy from their own individual actions as opposed to the traditional things happening to the girl at the initiative of others, or growing out of a situation in which the girl has found herself.

V. FUTURE CAREER IMPACT

After the girl has decided to take course work and pursue career goals in a science or technology area she will require competence in multilevel[16] game theory. The complexity of academic[1,6,13,15] or industrial[17] politics[18] overlayed on the technical accomplishments, provides a new baseline for optimal determination of multidimensional strategies. The fight for tenure in the university and then for full professor rank are analogous to the pursuit of various levels of industrial management positions. At these advanced career levels, the ability to learn technical skills scholastically becomes only the first level of a hierarchical system composed of a political interaction level (second level) and the mechanical steps leading to each career advancement (third level). Therefore, in addition to traits (1) to (13), the following four adult types of traits must be adapted:

(A) At an early stage of introduction to an individual, decide that person's standing with respect to your progress. This allows proper basic strategy planning with respect to a possible negative opponent.

(B) Turn all forms of negativism into something beneficial to your progress.

(C) Remove all negative influences from your life that cannot be dealt with by (B).

(D) Develope methods of releasing stress.

(E) Find a mentor or support person to turn to for guidance who has years of experience in your technical area.

In the references by Crawford, Newcomb, Hilbert and Roark, the present problems facing women in science and technology in academe are factually discussed. If traits (1) to (13) and advanced traits (A) through (E) characterized the technical political endeavors of the women described, their achievements would have more positively sustained the retarding factors built into science and technology advancement systems. Even when these traits are expressed widely in verbal and written form, their effectiveness at the advanced career levels will depend on the motivation of girls and women to incorporate the principles in day-to-day situations. Naturally, forced learning of these traits is not as effective as the gradual training which men receive. Unfortunately, it appears from the literature and my own academic and industrial experiences that girls' and women's behavior alterations will precede societal changes. The persons imposing the retarding factors in society to girls and women cannot easily be made aware of the situations they are creating for women's future careers. These persons do not have to live with the severe negative personal and financial obstacles which they inflict on girls and women in either a blatant or subtle manner.

VI. CONCLUSION

In science and technology we dedicate ourselves to the study of nature, the understanding of our environment, and the quality of life. Both women and men should be allowed to enjoy this great form of satisfaction if they are given equal opportunities from the time they are girls and boys. The game theory foundation of operation should be training for girls as well as boys during the formative years by parents, educators, textbook writers, and the media. This formerly societally unacceptable behavior in girls will encourage the persistence and determination required for pursuit of science and technology careers. In the ensuing years of the girl's academic work, having the right opportunities to do research[15] will involve a career committment which can only be developed gradually through years of strength of purpose and continuous development of an overall career goal plan. These methods for introduction of committment to encourage girls in science and technology careers were presented here as a result of my experiences and those of many other successful women[9].

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12. SPECIAL ACTIVITIES FOR WOMEN ENTERING ENGINEERING AT EINDHOVEN UNIVERSITY

Measures for making a better start for female freshman students of technology and the considerations underlying those measures.

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1. Background of the project

The main question of this conference is what can be done to make science, especially physics and technology more attractive to girls; how can we achieve that girls who study science and technology have the same opportunities as boys; and that they have generally the same results in science and technology as boys.

Generally, these same questions have concerned us in the department of Social Sciences at Eindhoven University of Technology for a considerable time already.

It is obvious for everyone that the number of girls studying technology is very small (at the moment at the E.U.T. the total is about 3%).

Only recently however this is being considered a problem. Until not so long ago it was accepted as a normal fact that girls were not be found in technology ("it has always been that way", "Technology is not suited for girls", etc.).

At this moment I think it is necessary to tackle the problem at different educational levels. It is important to concentrate on moments in a person's life when crucial education/career choices have to be made. Thus, work has to be done on the primary, secondary as well as the tertiary levels.

The higher the educational level, and the more scientific and especially the more technical, the smaller the number of women entering these studies. There are fewer girls at the university than boys (30%-70% resp.), while the distribution of girls and boys at the secondary level is about equal.

There are fewer girls than boys at the secondary level who choose a science curriculum (30%-70% resp.). The proportion of girls in science is much smaller when we look at the university level (for mathematics and the natural sciences the proportion of girls is 16%); and even smaller in engineering (the percentage of girls is only 4).
So apparently girls experience barriers when choosing science on the secondary level; but for choosing science on the tertiary level there are even higher barriers and for choosing engineering again higher barriers must be overcome.

The question was: how do we get more women to study engineering, and how do we prevent them from dropping out when they do start studying engineering?

It seems that more girls than boys drop out from their study in engineering. Poor performances cannot explain the higher drop-out level for girls. Social circumstances such as having babies, getting married, feeling isolated and finding the study too career-oriented seem to be an important factor in dropping out. I said "seem to be important". I haven't got hard proof for this statement, but interviews with students, deans and psychologist have given me this impression. Given the small number of girls who start a study in engineering, it is easily imagined how few women engineers we end up with.

It came to our attention that Purdue University in the US had developed and actually carried out a special programme for girls who entered engineering (1), based on research literature (2). It was started in 1976 and the results were very positive. In 1977, 9 times more girls studied engineering in the US than in 1969. At Purdue University 17 times more girls studied engineering during the same period. Of course, this could mean that the programme of Purdue University was so attractive that girls come to this university who would otherwise have studied the same subject at another university. This would mean that the total number of girls entering engineering did increase, but not necessarily because of the special programme of Purdue University. Also at Purdue University 78% of the women who took the special course remained in school, while only 62% of the women who didn't participate remained. This difference is, of course suggestive, although the two groups are probably not comparable in all respects.
Other universities and departments in the US also organized special programmes for girls in science and technology, all of them with positive results (3).

We took these results of several of the existing programmes as a starting point for our own programme.

One factor has to be stressed, however.

Organizing a special programme on a university of technology like ours, is not an easy matter. The standard study is very fixed and the programme full. The departments are relatively autonomous, which makes it difficult to do something on a central level. Therefore it takes a lot of talking to persuade (if you can) the decision makers to try out an action programme for girls, especially in view of the almost all-male character of this university.

And of course, as is the case everywhere else, the budget is getting smaller and smaller. This means that in your head you can make beautiful plans of what such a programme should look like ideally, but that in practice you have to make a lot of compromises.

Furthermore, it should be stressed that organizing such a programma takes a lot of time and energy.

2. Women's barriers and what was done about it

Engineering is not by definition a-female, neither are women a-technical by nature.

Formal barriers do not exist for females to enroll in a technical university. The barriers are of a non-formal kind. What are these?

The literature (2) tells us that girls who enter a study in engineering, as compared to boys in the same position, often

- have fewer "hands-on" experiences;
- have a more reserved attitude towards the unclear relationship between engineering and society; particularly the positive one;
- have fewer identification objects and role models, because there are so few female engineers;
- have fewer possibilities of having informal contacts with other girls, students as well as engineers.

These barriers could possibly be lowered by:

1. offering a learning - or practising situation which gives the girls the possibility to get practical experience, to handle tools and machines and to get used to a technical vocabulary.
2. making the relation between technology and society clear.

3. presenting models of female engineers; also giving some insight in the position of women in general.
4. stimulating informal contacts between women.

These points will now be considered individually.

2.1 Experiences with tools and machines

Although technical hands-on experience is not a necessary condition for following a study at universities of technology, women probably lag behind in this respect. We can speak of an unequal starting position.
Being unfamiliar with tools and machines can also be a psychological disadvantage, because people feel that they are expected to be familiar with them. To make the starting position more equal practical learning situations were organized. We assumed it would be advantageous to get the girls acquainted with big machines, which is rough and where you get your hands dirty, and also with small tools, which is another way of being busy with practical work.
Also we thought it would be too large for one department to handle. This was indeed the case. Twenty-nine girls participated. The department of Physics could handle twelve girls, the department of Mechanical Engineering the other 17. Choosing specifically Physics and Mechanical Engineering was mainly dependent on the easy coorperation with the people there.
In the department of Mechanical Engineering the girls made a plummet. In the department of Physics the girls made an electrical doorbell.
Attention was paid to the following skills:

- skill in technical drawing
- use of measuring devices
- simply electric assembly techniques
- use of hand tools like sawing, filing, scouring and bending
- using wire-cutting tools

The idea was to work towards a finished product, which could be used in daily life. We thought that this would be motivating the girls.
The technical skills that were needed were all very basic.

2.2 Making the relationship between technology and society clear

Nowadays, technology is often profit oriented and used for military purposes. The discussion about the arms race dominates present day politics, and with that to a large extent the appearance of technology. This is a one-sided use of technical know-how, which also makes itself felt in technical education.

The relation between technology and people and society is not very clear, neither in the curriculum nor in the profession. There is reason to believe that engineers are more interested in things than in people; women in general seem to be more interested in people than in things. Women who are interested in technology, seem to be more concerned about the social implications of technology than men and it also seems that women fear misuse of technology more than men (4).

Attention should be paid to the fact that technology does not only exist for making profit and for destructive purposes, but that technology can also be constructive (protection of the environment, saving of energy, health service etc.).

Furthermore, attention should be paid to how technology affects people and society in general: it is important to make clear that technology is made by human beings and should be controlled by human beings.

Another point is the following: technology now, is a men's business. This is also noticeable if you look at research questions being posed. Is it possible for women to have a contribution of their own, which is corrective and/or complementary? Like, for instance, the question of the existence of the so-called "dormant" cities and their influence on the position of the women who live in them. Does it cause isolation? if so, and if this is considered undesirable, shouldn't this have consequences for planning and policy in the construction of houses?

A woman engineer was invited to keep a seminar on the subject mentioned above. Discussion was possible.

2.3 Presenting models of female engineers: also giving some insight in the position of women in general

As was said before, technology is mainly a men's business. Therefore technology has a male "image". This can be seen in books for children, in which boys are shown with "technical" toys and girls with dolls and kitchens. In school books an engineer is referred to as "he, who ...". Most of the teachers and students in this field are men. Because of this technology may become unattractive to women who are looking for an identity of their own. Attention should be paid to the fact that there are female engineers; how do they see technology, where do they work, what kind of work do they do, what kind of family situation are they in, what are or were their problems in getting a job, discrimination, appreciation etc. Giving more insight in these matters can make it easier for the female students to form a professional image for themselves; they can also prepare themselves better and defend themselves against the unpleasant situations with which they will probably be faced.

Monday morning an informative lecture was held by a female engineer about job possibilities for female engineers.
Tuesday afternoon a panel of six female engineers was organized. These women had done different engineering studies, were working in different areas and had different family situations. They each spoke for about fifteen minutes about their experiences as students and in their job.

Although the position of women in technology is not identical to the position of women in general, one can draw parallels on the basis of being female. Two films were shown, one about the position of female students in general, and one about female workers in general.

2.4 Stimulating informal contacts between women

There are very few female students at the university of technology. The ones there are, are spread over different departments. This doesn't make it easy to come into contact with other women at the university of technology (it really resembles a big factory). This is not particularly enjoyed by female students. So possibly making these contacts should be facilitated.

This is done by getting together as many women who enter engineering as possible for at least the whole week, in which the activities 1, 2 and 3 are done.

Meals, coffee, tea and evenings are also used/spent together.
One evening female staff members and women who had been students for a number of years already both from the E.U.T. were invited. The staff members, to show that they are there, who they are, where you can find them, and what they are in for. The students to give the participants an impression of what life is like as a female student at this university of technology.

3. Evaluation and further action

At the time this paper was prepared, no evaluation results were known. Probably, these results will be available at the time of the conference.

The initial enthusiasm to participate was very high. Of the girls who were invited and who did enroll at the university of technology 82% (= 27 out of 33) participated.
After the invitations had gone out, sixteen more girls entered the university. For practical reasons, it was impossible to include them in the project. The question remains how many of these sixteen girls knew of the existence of the pre-introduction week. Two of these sixteen contacted the project leader in time and could also participate. Thus, there were 29 participants in all.
We'll try to find out why the six girls who did enter and who were invited did not participate. Because of the small number (6) we cannot draw any hard conclusions about their reasons.
Also we'll try to find out how much the fourteen girls who were not invited knew about the pre-introduction week and if they knew anything at all about it, what their thoughts about it were.

Follow-ups will be held. One after the first and one after the second semester.

During the coming years we'll keep track of the drop out and entering rates, and also we'll try to find out the why's of it. It will be difficult to draw any conclusions from future enrollment rates of women, even if they do rise, unless they rise extraordinarily; because the possibility always exists, as may have been the case with Purdue University, that our programme is only attractive in so far that girls now come to Eindhoven, who would otherwise have gone to one of the other universities of technology in this country.

More can be said of the drop out rate, because we have a comparison group; 29 women who participated and 19 who did not.

We also plan to have informal gatherings with all the girls who entered engineering with a frequency of one each month. This is how the participants wanted it themselves. One fixed evening, because continuity is very important. All kinds of activities are possible during these evenings and in between; telling each other of their experiences, informal talk, inviting other people to give seminars, going to the theatre, etc..

4. Programme (the 10th - 14th of August 1981)

Monday

10.00	coffee
10.15	introduction attendants and programme
10.25	getting acquainted
11.00	introduction about possibilities for the future for female engineers
11.45	questions/discussion
12.30	lunch
13.30	practical learning experience
17.30	closing of the day
20.00	getting to know each other better

Tuesday

9.00	practical learning experience
13.00	lunch
14.00	panel of female engineers
15.30	tea
16.00	discussion panel
17.30	closing panel
20.00	informal gathering with senior students and staff members

Wednesday

9.30	practical learning experience
13.00	lunch
14.00	introduction about the relation between engineering and society
15.00	tea
15.30	questions/discussion
17.00	closing

Evening: going out

Thursday

10.00	coffee
10.30	making plans for future activities
11.15	films about the position of the female student and the working woman in general
12.30	lunch

The rest of the day of

(Originally, the intention was to show one film during the morning and one in the afternoon, with discussion following; and make plans for future activities in the evening. By wednesday-evening the project leader got the feeling the programme was too much for the students. So thursday morning she asked the students what they wanted to do during that day, giving them a few alternatives to chose of . The programme mentioned above is what they choose.)

Friday

10.00 excursion Medical Systems
12.30 lunch
13.30 evaluation by Educational Research
15.00 closing of the week / drinks

During this week the girls stayed in a youth hostel near Eindhoven. The project leader was with the girls all the time.
Participation was voluntary and free of charge.

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13. Intervention strategies in favour of girls' achievement in science (physics) and technology in the MENT-project.

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Introduction As is well known to the participants of the GASAT-conference girls have a disadvantage in science-and-technology education. In The Netherlands as in other Western countries in all cases where girls can make a choice they take less science (especially physics) and technology than boys do. And when they indeed choose these subjects on the average they achieve less than boys.

For a number of reasons we do like to change this situation. Here we just mention two of them. Firstly, the changing role of men and women so that women more than in the past should have a fully equal opportunity as men have in making their own career. For many positions directly after secondary education or after finishing higer education the knowledge of science and technology is wanted. Secondly , when by irrealistic reasons women can't choose to study science and/or technology as men can, one loses talent.

In the MENT-project we want to create a situation where girls are encouraged to choose science (especially physics) and/or technology as boys can.

MENT stands for ME (=MEisjes = girls), N(=natuurkunde = physics), T(= techniek=technology). The MENT-project has to do with students of 12-15 years old, the lower part of secondary schools.

The Dutch situation In raw lines children attend primary schools from 6-12 years. At the age of 12 they enter secondary schools. There are two kinds: those for general education (about 60% of the population) and for vocational training (about 40% of the students). The last sort of schools mostly is visited by slow learners and children of the lower social families.

We have three different kinds of schools for general education, in the rank of more academic character: the mavo (about 25% of the population), the havo, and the vwo (together 35% of the pupils). In most schools, having in the organization the havo and the vwo, the schools have a common first year. The vwo-schools are preparing for entering the university.

In all kinds of secondary schools for general education the mavo, the havo and the vwo, the students follow on the average in the first three years these number of weekly periods for biology, physics and chemistry:

	biology	physics	chemistry
first year	2	0	0
second year	2	2	0
third year	0	3	3

TABLE of the weekly periods in biology, physics, chemistry,as -on the average- given in the first three years of mavo, havo and vwo.

In Dutch secondary schools one does not teach science, but separately biology, physics and chemistry. In schools for general education hardly any lesson is given in the field of technology.

In The Netherlands there is a rather strong movement to an all comprehensive 'midden-school' for the whole population of students of 12-15 years old, the full range of lower secondary education.

Our work primarily deals with the mavo, havo and vwo, the first three years. We do this to make the MENT-situation rather clear, restricting us, in this contribution, also to physics.

Intervention strategies in the MENT-project We like to create a situation where girls are as succesfull as boys are in the physics lessons. We do this to promote girls choosing physics as easily as boys do.

In the first three years of secondary education the subjects biology, physics and chemistry have to be followed by all students. This is the situation for all subjects of these years. At the end of the third year students can make choices. A student, at the end of the third year can choose to follow physics in the next year, ór drop it! So when looking for *strategies* to favour girls' achievement in physics it is a rather good choice to do one's best to influence the physics lessons in the second and third year of mavo, havo and vwo schools.

Of course it is important to pay attention to the science education in primary schools, as it is a real good thing to promote girl-friendly physics lessons in the higher part of secondary schools too. But one cannot do all things at once!

The MENT-project firstly has to do with the lower part of secondary education. To make a start we begin with general-education schools.

We don't look only at the effect of more girls choosing physics in the higher classes. The physics-curriculum for the second and third year should be important for girls (and boys) at its own merites. We also want girls, when not choosing physics in the next classes, to have a clear knowledge of physics, as can been given to students of this age in a rather small number of lessons.

How can we reduce girls low achievement in physics in the second and third year of havo and vwo, in such a way more girls choosing this subject in continuing study?

We are looking for four ways: (1) making physics lessons more inviting to girls by changing their content, (2) making teachers aware, or more aware of the bad situation of girls in physics lessons, (3) making the material, i.e. the physics text books, more friendly to girls, (4) using what others found (literature, other similar projects, the GASAT-conference !).

(1)Changing the content of the physics curriculum in favour of girls' achievement sounds rather confusing. We won't make physics just easier and at that doubtful way 'semi'-more attractive. But when thinking of all male examples in physics-lessons, the image of physics as an activity for male occupations, thinking of the curriculum as made nearly only by men, one really can wonder if one cannot change the content of the lessons even within the curriculum to make physics more inviting to girls. Maybe we should use, e.g. more examples of phenomena of the human body as the energy-balance.

In the past we taught many things to rather young children, we here think of students in the age of 12-15 years old, which we now know many of them had very much trouble to understand both by the way of presentation in a wide sense and by the content of the curriculum. I won't declare here we should only follow what Piaget cum suis found. We also have to use the modern findings of East European psychologists in the development of the way children think and learn.

What I just like to make clear is that we seriously have to look after possible changes of the physics curriculum to make physics more attractive and inviting to girls.

Let me give an other example. As is pointed out in literature, girls may have a more positive attitude to physics when the lessons have more to do with physics as seen in the daily life. In The Netherlands, as in many countries, the physics-curriculum for 12-15 years old students has been much changed into this direction during the last decades. Maybe we have to change more. When we like the physics lessons to be inviting and creative to young children we should offer them a physics-curriculum that appeals for the experience of the daily life. Physics is not only an abstract science, only practised by theoreticists or technicians, far away of children's experience of each day.

We can promote a more girl-friendly physics education by trying to make physics-teachers more friendly to girls. But we also have to look at the content of the physics lessons, up to now given on the basis of men-made curricula.

(2) Paying attention to the role of the teachers: they should be aware of the negative position girls have in physics-lessons. In lessons to a class of about 24 children, 12 boys and 12 girls, it seems as if all students have the same chances in getting an equal benefit of the lessons. To know better one should only observe the average way girls and boys attend lessons, how they co-operate (or not co-operate !), how the teacher interacts with the girls and with the boys.

For this reason we made video-tapes. We are developing more, surely for use in discussions with teachers.

> Here I refer to paper number 20, Mathieu Dumont, *Case study of the pendulum-experiment.*

So part of our efforts must be directed to teachers. Maybe the biggest succes at the moment comes from changing teachers' attitude.

As is well known this means more than just telling in-service and/or pre-service teachers they should be more friendly to girls. This kind of changing one's attitude takes more attention and more time. One has to make a certain *strategy* and to make a middle long-term series of activities.

At this point I remember the reaction to the promotion of the subject 'girls and physics' in a yearly national conference of physics-teachers. Rather many of the participants only could laugh at a suggestion like this. At the other side I have to mention that the following year there was quite some interest for a discussion of the problem.

> At that opportunity we did write a Dutch report with a rather extended English summary, Jan H.Raat, Ilja Mottier. *Marie, word wijzer ...van natuurkunde.*
>
> *Meisjes en natuurkunde. ('Mary, wisen up by physics).*'s-Gravenhage, 1980.

When looking at the problem of making teachers aware, or more aware, of girls' positions in physics education, one can see growing interest for the subject; one also can see that much work yet has to be done in this respect.

Especially teacher training institutes have to pay attention to this topic.

(3) Physics textbooks seem to have been written for boys only. The text mentions boys and men, illustrations show boys and men, examples are taken from what is considered as male interests: construction kits, cars, engines, sports like football.

> As for the content of physics textbooks we refer to paper number 10, Ilja Mottier. *Girls and physics in the HANDROVER-project.*

Where no new curricula are available and the existing methods have to be used, still changes can be made. The existing textbooks reflect in no way a world where women are taken in account. Illustrations often relate uniquely to industrial situations. Teachers when giving physics lessons should however give other accents too.

(4) We should be very unwise to try to solve a problem like we are writing about without using what others found. And I think, we have to come in action now! We should not only study girls' negative attitudes to physics and seek the reasons of it. When going on into more investigations, as is necessary, at the same time we can try to make a beginning in tackling the problem.

But using what others already found.

We contribute negatively when thinking at short time succes only. The problem 'girls and physics' is a rather complex and difficult one. When trying to promote girls' achievement in physics one has to look for close co-operation with others, working at a similar project!

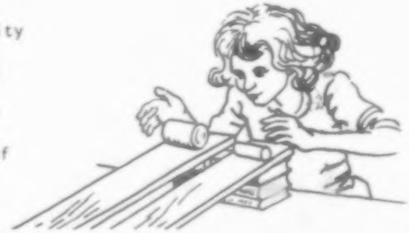
Dutch physics-curriculum-projects Some of the experiences I got in physics-curriculum-projects can well be used in the MENT-project, the choosen strategy of curriculum development having a real good influence on teachers' behaviour. For that reason some attention is paid to the DBK-na project and the NAS-project.

In the short description also some remarks are made on the activities in the MENT-project.

DBK-na stands for Differentiatie-Binnen-Klasseverband (=differentiation-within-the class, i.e. mixed ability teaching) for the subject physics (in Dutch 'natuurkunde', abbreviated by the two letters 'na').

In this project we created a curriculum for physics to be used in, again, the first three years of the mavo, havo and vwo, it means in the second and third year, the teaching of physics in secondary schools starting in the second year. The background of the project has to be found in the Dutch movement towards an all-comprehensive 'midden-school' for 12-15 years students.

The curriculum was constructed by our small department of physics-teacher-trainers (Free University, Amsterdam, the university I was connected with at that time. We did it in close co-operation with physics-teachers of schools out of the whole country. It is important to have a curriculum-development-project with full-time teachers. By doing this the curriculum has a big chance to be really used in schools. A second advantage is the positive attitude of the teachers to the new curriculum. I here talk not only of the teachers, writing the curriculum with us. I also think at this moment of others, using the curriculum when it was finished. The first enrolled teachers played a fairly important role in the in-service training of new teachers-users of the curriculum.



In the DBK-na curriculum we made some measurements of students attitude to physics, just at the beginning of the second year. They then have hardly had physics lessons. We can say it is the attitude the students have when starting physics. here give some data, as have been published also in the report *Marie, word wijzer ... van natuurkunde*, I referred to before.

scale	girls	boys	significancy of the difference
pleasure in physics	2.58	2.67	.02
interest in physics outside the school	2.03	2.29	.00
importance of physics	2.64	2.83	.00
physics too difficult?	2.20	2.62	.00
'clarity of purpose of physics-lessons'	2.38	2.54	.00

TABLE of some scales of students attitude to physics (ranging 1.00-5.00), as have been measured in the DBK-na project, of students at the beginning of physics-teaching.

Here we see, as one might know from other investigations, the less positive attitude of girls, already at the beginning of the physics-lessons. As has been written by Alison Kelly also, one can see girls' negative attitude to physics as one of the important causes of their limited succes in these lessons. When looking for a strategy to change girls'situation in physics teaching, one has to pay much attention to change their attitude to the subject.

The NAS-project

NAS means NAtuurkunde in de Samenleving, i.e. Physics in Society. We wrote this curriculum again in close co-operation with many teachers. The idea of the curriculum is to spend more attention to the meaning of physics for society, and, from the other side, the influence of society in e.g. physics-research-programmes. Let me only think of investigations to solve the energy problem; also of the big and expensive research for making new, and very dangerous, weapons. We disliked the situation of teachers giving physics lessons with no or less attention to the relation of physics and society. The curriculum has been written for the sixth (the last) year of the vwo-schools, to be used in about 15 lessons.

The curriculum has been edited: Eijkelhof, H.M.C., E.Boeker, J.H.Raat, N.J. Wijnbeek. *Natuurkunde in de Samenleving*. Amsterdam, 1978.
An English edition is published: *Physics in society*. Amsterdam. 1981
(ISBN 90.6256.241.8).

The important thing, to be mentioned here, is again the fact of the close co-operation with full-time teachers. Though talking on the basis of teacher's experience ourself, we do not teach any more in secondary schools. So, thinking of a 'Physics in Society'-

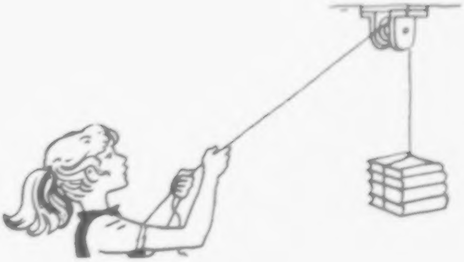
curriculum, we must avoid writing it just from the office, from the desk. One also has to use daily fresh experience of many others, working just in the field the curriculum has to be used in.

So, when thinking of developing material for physics-lessons, more inviting to girls, we are sharing our ideas with those of teachers, creating curricula and parts of it together.

To avoid misunderstanding, we are't going to make a special physics-curriculum girls! What we are looking for, when thinking of changes in the curriculum, are small parts of the curriculum. We think of curricular material for a number of e.g. 5 or 10 lessons in the second class; another 5 or 10 lessons in third year classes. After that experience, and close looking at the results and the effects, however difficult it might be to come to reliable data, we may go further.

Final remarks We just are starting the MENT-project, so we cannot mention any results at this moment.

For any reaction or suggestion, for any kind of co-operation in this project or a similar one: we are looking forward to it.



14. The 'Changing Attitudes'-project
General Report on the work done in the 1-st semester of 1981

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The following activities were undertaken during the first half of 1981 within the framework of the "Changing of Attitudes" project:

1. Cooperation with the Ministry of Education;
2. Working out and adaptation of written, visual and audio-visual material;
3. Work with teachers from schools involved in the pilot experiment as well as with Teachers' Training Colleges;
4. Children Literature Seminar;
5. Other information and awareness campaigns;
6. Surveys on attitudes.

1. Cooperation with the Ministry of Education

Throughout the school year, the 'Changing attitudes' project was carried on in close cooperation with the Ministry of Education, having the latter carefully follow all activities undertaken in every field thereof.

Thus, the 'Direcção-Geral do Ensino Básico' (Basic Education) sent representatives to many meetings attended by teachers from schools involved in the pilot experiment, and also joined the project staff visits to Teachers' Training Colleges for awareness campaigns intending teachers and pupils as well as for helping with teachers' continuous learning. Moreover, the said Board made it possible for teachers, students and headmasters of Teachers' Training Colleges countrywide to attend meetings organized within the framework of the 'Changing Attitudes' project, most of which were held in Lisbon. In such cases, the aforecited DGEB bore travel and board and lodging expenses of a large number of participants e.g. on the occasion of the Teachers' Meeting (held in April) and the Children Literature Seminar (held in May).

Furthermore, the project granted assistance to teachers' continuous training, by planning activities along the guidelines of 'Changing attitudes' meant for the 1981-82 schoolyear, since the Ministry of Education is supposed to further such activities which have already started, of which the Portuguese-Swedish cooperation scheme is brought to an end.

2. Written, visual and audio-visual material design and adaptation

During the first half of 1981, written, visual and audio-visual material was being worked out and adapted under the project.

a) Written material

A book whose title is 'Girls and Boys, same world, same tasks', already mentioned in the previous report, has been published by now. Primary School teachers are supposed to use it as a basis for stimulating debate and reflection. Teachers can resort to supporting texts already drafted, to develop some topics under the current Primary Education syllabus - such as trades and economic activities or leisure time.

As early as the next schoolyear, this book will be circulated in all schools related to Teachers' Training Colleges countrywide.

A folder was moreover drafted and printed, which gives information about the targets set out in the project.

b) Visual material

* Project Symbol.

With a view to more easily defining and identifying the project, it was deemed important to design a symbol which will be printed, from now on, on all materials worked out under the project.

* 3 posters for youngsters and growing-ups of both sexes: two which are black-and-white photos showing a boy who rejects masculinity standards imposed on him by society, and respectively a girl who is delighted to assume her femininity, but refuses to be a victim of her condition. As for the third poster, it shows a typical Portuguese

'azulejo' (ceramics) on which a folk-taste quatrain is printed.

* Balloons with the following words:
'Boys and girls, same world, same dreams'
'Girls and boys, same world, same games'.

* Plastic bags reading the 'Changing attitudes' project symbol and the words: 'Women and men, same world, same tasks' and 'Women and men, same world, same concerns'.

* Stickers conveying the idea that both sexes have to be given the same opportunities.

c) Audio-visual material

* The Portuguese 'voice-off' version has been made for the film 'The Double day' which was acquired in the first semester; this film is especially meant for awareness campaigns in Teachers' Training Colleges.

* The two sets of slides mentioned in the former report are still under way.

* A 30 minute film is being shot, which shows the way children live with sex-based roles, as well as the contribution made by school and teachers in changing attitudes.

The snapshots were taken from some pilot schools involved in the project and from the Teachers' meeting held in April, mention being made thereof under item 4 of the present Report.

The relevant snapshots have already been taken and their selection is under way at present. The film is meant for teachers' continuous training as a first call of attention.

3. Work with teachers in schools under the pilot experiment and with Teachers' Training Colleges

During the semester corresponding to the second part of the 1981 schoolyear, intervention activities were carried on in schools involved in the pilot experiment. Throughout the relevant time-span, teachers were systematically testing activities oriented towards changing the pupils' attitude vis-à-vis sex-based roles. Activity testing was always preceded by an introduction and debates with the participation of both discussion leaders and teachers, about the targets and content of each activity followed by the relevant assessment.

After the assessment of the work done in every school had been started as early as in March, the necessity was felt to change the methods used so far, i.e. the meetings split into two clearcut parts: first, a series of activities being presented, and second, an assessment of activities already implemented. Thus, such meetings became an opportunity to assess and discuss the output of the activity testing. It was deemed more suitable indeed to introduce the other activities as a whole, trying together with the female teachers to insert them within the current Primary Education curriculum, thus enabling pupils to deal with them in a more spontaneous fashion by assimilating them into their day-to-day work. At the same time we did the outmost to tune our suggestions to the different age-groups of children involved in the said experiment.

After completing each exercise or activity, teachers were required to fill in an assessment schedule especially designed to sum up concerns about the implemented activities.

A meeting of teachers was held in April for the evaluation of the pilot experiment stages in the 4 Primary Schools concerned, as well as the work done in changing attitudes towards the sex-based roles at the level of Teachers' Training Colleges (mention being made thereof below). Attending were most of the schoolmasters, teachers and monitors who were involved in the project in a way or another.

Furthermore, the meeting highlighted the necessity to further the work done along these lines and the ways and means to translate it into practice. Some recommandations were thus drawn about the subject, which were subsequently submitted to the Ministry of Education with a view to gradually being circulated through channels somehow linked to teachers. Starting from such suggestions, we also drafted a recommandation for a protocol to be concluded between the 'Comissão da Condição Feminina (Women Condition Commission) and the Ministry of Education. Should the protocol come into force, the project could be furthered at the Primary Education level after the completion of

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the regular cooperation scheme between Portugal and Sweden, also creating suitable conditions for the project to be extended to other Education levels.

The stage of intervention among the pupils ended up with another session of tests or questionaries which had already been applied at the beginning of the experiment (October and June) with the aim of gathering elements for assessing an evolution in their attitudes.

After concluding the implementation of such undertakings (in between the teachers were interviewed in sub-groups and the interviews were taped, thus enabling the oral means of expression to highlight certain facts of the experience lived by teachers and pupils which had been skipped during the ordinary activity-assessing meetings. This was an important step indeed, since most of the elements collected were vivid examples of the way in which children's activities had been evolving.

To complete intervention in pilot schools, the discussion-leaders suggested that a meeting should be held in which they themselves presented to the participants an overall assessment of the intervention implemented in several schools, bearing in mind the different stages, targets, methods, degree of participation and involvement in this work as well as the level of discussion about the contents of such undertaking as were reached on the whole in every session.

As to the work done in Teachers' Training Colleges, awareness campaigns were launched in various schools in Leiria, Caldas da Rainha, Faro, Viana do Castelo, Penafiel, Aveiro, Braga and Lisbon. Such sessions brought together teachers and students from Teachers' Training Colleges and from ancillary establishments, Primary Schools where future teachers undergo practical teaching training, as well as teachers and pupils from Nursery Educators' Schools. Further activities were carried out in Leiria and Faro with teachers already in exercise undergoing continuous training actions.

The main target of such activities was to reflect/debate upon the position held by Women and Men at the different levels of our society with a view to arousing growing awareness resulting in the setting up of a group responsible for this course of action in every School, with the support of the CCF.

Owing to the ever wider scope of this project as well as to the fact that the pilot experiment in the Great Lisbon District Area has reached the assessment/completion stage, it has not been possible so far to encourage action in Teachers' Training Colleges, so that this work is planned to be resumed in September.

The aforementioned schools sent their representatives to the Meeting held in April, where they could voice their opinion about the project and the advantages deriving from a continuous course of activities of this kind in Primary Teachers' Training Colleges. (See survey report and recommendations issued at the end of the Teachers' Meeting.)

A meeting was also held last July which brought together representatives of the said schools to debate upon activities suggested for the schoolyear (c.f. CCF - MEC Protocol).

In September a meeting is scheduled to be held in Lisbon with the participation of all Teachers' Training Colleges countrywide, aiming at working out a course of action along the 'Changing attitudes' path. At the same occasion, the Ministry of Education will be notified of the names of the teachers who will undertake to co-ordinate the implementation of the relevant program in every Teachers' Training College, and will officially ascribe to each one a certain number of hours for this purpose.

4. Children Literature Seminar

A Seminar was held the 18-th to the 19-th of May which dealt with the following topic: 'Children Literature: its contribution to better balancing sex-based roles'.

This seminar was sponsored by the 'Comissão da Condição Feminina' with the participation of a member of the Basis Education Board; its objective was to debate upon the way children literature can help to a better balance between female and male roles.

The proceedings were opened by the Head of Office of His Excellency the Deputy State Secretary of the Prime Minister on the latter's behalf and the last session was closed by the Director General of Basic Education - a lady-director general - on behalf of His Excellency the Minister of Education.

We found it necessary that female and male characters depicted models which children should imitate, be not only a mirror of our reality but also a way to suggest new behaviour patterns.

It is important that books point to new types of relationship between chilren; to new female and male roles; to more balanced male roles; women playing more efficient and active roles in today's society.

It was on these grounds and in this very spirit that we organized the Seminar and suggested these topics for discussion. Thus, a forum was opened to writers, designers, representatives of publishing houses, headmasters and infant school teachers, teachers of Portuguese and children literature from Teachers' Training Colleges and Nursery Educators' Schools, journalists and people responsible for children broadcasts within the media.

The seminar enjoyed the participants of two lady-experts in the field, namely Dr. Ying Toijer Nilsson from Sweden, who submitted a paper dealing with sex-based roles in children books, setting out from an overview of the evolution of the Northern and Anglo-Saxon literature over the past 20 years. It was a highly valuable analysis, showing the way people relate to children literature can contribute to a better knowledge about the spreading of sex-based stereotypes and their evolution process in the author's country, Sweden. The next day, Dr. Ivone Leal dwelled on the Portuguese situation in a paper whose title was 'Stereotyped portraits in children literature. Some examples from the Portuguese literature'.

Both papers were copiously illustrated by visual material through the speeches delivered by the two lady-speakers. They were followed by debates upon the relevant topics in plenary sessions, with the active and lively participation of about 150 persons attending the seminar. In the afternoon sessions the public split up into small groups for further reflection, involving most of the participants in the seminar.

A great number of written materials, including studies already published, texts of the conferences delivered and supporting texts for group debates, were circulated among the participants at large.

The proceedings of the seminar called forth a deep response both from press and radio broadcasts. In our opinion, this seminar was extremely valuable thanks to the large audience it brought together as well as for having provided a forum devoted to a topic which has become a matter of concern for an evergrowing public on account of its importance in changing attitudes.

5. Other information and awareness campaigns

Bearing in mind that mass-media are playing an outstanding part in disseminating ideas relating to changes in male and female roles within the framework of our society, we endeavoured to establish personal contacts with journalists working in various newspapers and magazines in such sections which, in a way or another, have to do with Feminine Condition problems. Contacts have been established with people responsible for radio and television broadcasts, with a view to attracting their attention to the objectives set forth in the project. Besides, texts describing the targets, actions and material of the project have been drawn up and circulated through all mass-media channels.

Moreover, information and awareness campaigns were carried on involving trade-union bodies, cultural associations, groups undergoing illiteracy-eradication training, scouts, a.s.o..

Project-inspired posters as well as the issue 'A boy, a girl' formerly launched under the project, were sent out to the teachers of Portuguese in all Secondary Schools countrywide on the occasion of Women International Day, the 8-th of March. This issue was meant to both teachers' and pupils' awareness of the necessity to think of a debate on the sex-based roles topic.

During the first quarter of 1981, provisions were made under the project for participation in the 'FIL-Juventus' April display (FIL stands for Lisbon International Fair). This Fair has yearly displays in Lisbon and is open to all youngsters regardless of the age group they belong to as well as to infant school educators and

and education-related staff. On the occasion of this ten-day display, we tried our hardest to launch a far reaching information and awareness campaign about the project and its guidelines, by circulating a wide range of materials especially designed for this purpose and taking into due account the different age groups of children, teen-agers and grown-ups - to whom our message was being conveyed.

6. Inquiries in Attitudes

A relevant sample of the Portuguese population was involved in the public opinion survey on certain fields which are telling examples of the outlook expressed in connection with the roles women and men are playing in our society.

As far as family attitudes are concerned, the field investigation started as early as last December and this work is being furthered at present by an analysis of the content of the gathered data, which will provide more follow-up work in the second half of 1981.

(Note of the editors. Due to defective copy, some words had to be restaured by the editors. We hope this didn't affect the essence of the author's text.)

15. Women in Science: A Developing Country

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Because teenaged girls generally avoid classes in physical sciences and advanced mathematics, they reduce their career options. Even highly talented young women do not pursue science in numbers proportionate to their share of the college student population.

One way of examining this problem of underrepresentation is to recognize that women have been effectively isolated from the kinds of encouragement, feedback, and experiences that their brothers have been provided in family, educational, social, and occupational situations. Independence in thought and action rarely wins praise for a girl, and mechanical as well as intellectual attainments are likely to get approval only if they are expressed in "feminine" arts and services. This "Balkanization" of occupational choices and roles impoverishes many human endeavors. As Plato said over 2000 years ago, "Nothing can be more absurd than the practice that prevails in our country of men and women not following the same pursuits with all their strength and with one mind, for thus the State, instead of being a whole, is reduced to a half."

Without personal experience in active exploration, young women develop a "split-perceptual" view of science. They recognize that scientists do, indeed, manipulate materials and ideas to gain more information but they themselves would consult a book or ask an expert for advice if they wanted to know about unfamiliar materials in hand (Simonis, 1978). This "Bible and prophet" approach to gathering knowledge is similar to the instructional strategies used in developing countries where science is not a familiar aspect of the culture. The anti-authoritarian spirit of inquiry is foreign to the tribal (family) consensus-seeking and cooperation that traditionally favored survival in small communities.

Also, the most familiar, domestic tools of science are not universally beloved by women. Most of them have been designed by men, including such personal and specifically women-related objects as baby bottles, contraceptives, and abortion techniques. Many others are used more for destruction than for the service of life (e.g. lasers, ballistic missiles, nuclear weaponry). In short, the image of science and technology as an aggressive, competitive pursuit by people who like to have control over others is not compellingly attractive to persons who see themselves as acted upon by its enterprises. American science has raised anxieties about the environment and its ability to substain us at the same time that it has reduced women and many men as well to the role of passive consumer and victims. Could any colonial power do more?

To help break students away from strictly rote learning, from passive acceptance of the "magic power" of a teacher's or scientist's knowledge is the greatest challenge to science educators in developing countries (Moravscik, 1974). It is also the greatest challenge to creative thinkers - to break away from the "accepted" answer and conventional modes, to explore alternatives imaginatively before critically evaluating them and making choices. Girls are perhaps less likely to take intellectual initiative without direct encouragement to do so. (Eggleston, Galton and Jones, 1976; Kagan, 1964; Maltzman, Brooks, Bogartz and Summers, 1958; Ogunyemi, 1972). But there is evidence that their creativity, assertiveness, and willingness to take more risks can be directly encouraged. My own research (Simonis, 1978) gives evidence that development of verbal analogies related to physical phenomena encourages creativity in young women. Also, the manipulation of objects in a non-directive, student-oriented laboratory environment enhanced figural creativity which, in turn, may be related to spatial abilities and engineering skills. Hands-on-activities also effect shifts in girls' preferred modes of learning, favoring more active, experimental initiatives.

Research by a few, and assumption by many, are that role-models or same-sex mentors are highly important for women (as they also have been for men). Some strategies for increasing oppurtunities for such interaction on a one-to-one basis will follow. Less personal examples chosen by some textbook writers are inclusion of brief biographies and pictures of pioneering women mathematicians, engineers, and scientists in appropriate curricula. Another assumption (validated by statistics that women from single-sex colleges were disproportionately represented in the small corps of women scientists in the U.S.) is that young women are more likely to succeed in science and math if they are not isolated as "the only" or "one of a select few" in those courses. When women are a small minority registered for a particular discipline, aggregating them in one class, laboratory, science club, or housing unit may help develop a peer support group to reduce feelings of isolation and to develop strategies for coping in a "man's world" where sexual harassment and pressures to conform to stereotypical models can be very intense, especially among teenaged youth.

The sense of community, of social responsibility, and of appropriate response to significant others seems to be still very strong among young women, and they often de-select themselves from math and science courses because the relationship of such curricula to their perceived roles is seen to be a conflict. As Walter Scott Smith has reported (1976), Kansas City high school students who had been pre-identified as math- and science-talented predominantly stated that a long-term career commitment would interfere with children/spouse responsibilities. The perceived conflict between career and parenting was the most significant barrier anticipated to choosing a science career.

Dr. Smith also reported that a sub-group of high school students later attended a one-day career self-awareness workshop at the University of Kansas. During the six-hour workshop, subjects examined their own interests and capabilities, explored factors (including barriers) affecting their decision-making, discussed capabilities and career aspirations with their parents and/or each other, re-examined their ideas about a woman's pursuing a traditionally male science career, and talked with professional women already in such careers. Workshop leaders helped the group explore barriers (especially role conflict) during the discussion with role models. Dr. Smith thinks that in science a perceived conflict of roles, and *not* a perceived lack of ability, was discouraging his study group from pursuing non-traditional careers. Similar self-awareness treatments may be instrumental in persuading young women to continue their educational preparation for science careers.

At the University of Iowa, I took the approach that young women (high school and college undergraduates) might benefit from greater "career awareness". The "Women in Science Career Workshop" sponsored by NSF and the Science Education Center in spring of 1980 featured 18 women scientists in various physical and biological sciences (excluding clinical ones where women are now well-represented). They talked not only about the challenges and joy of their work but also about the family/spouse compromises necessary and resolution of limits to time and energy. The 145 participants had pre-registered their interests in securing discipline preparation and employment-related information as the reasons for coming. But the post-evaluations revealed that the primary benefit of the 2-day workshop was the rapport developed among the professional scientists and the support and encouragement they gave to the young women participating. As Alma Lantz (1979) has noted, girls perceive science careers as a lonely life and one incompatible with women's potentially discontinuous work patterns and child-care commitments. This perception was modified somewhat by seeing and hearing that women scientists were still women (not "imitation men"), that a variety of lifestyles and career options has been selected by succesful professional women, and that attractive role models are "out there" and eager to encourage upcoming young women to join them.

The workshop had a positive effect on attendees who subsequently raised their career aspirations and/or newly resolved to pursue a career in science, engineering, or mathematics. In order to extend its benefits and to further develop a network of informal career counselors and potential mentors for young women, I then sollicited volunteers among women scientists in Iowa who would be willing to talk to individual students or classes and/or give public presentations at future conferences. This roster of 253 local scientists and science educators was then compiled into the Iowa Directory of Women in Science and one copy each was distributed to every high school, college, and junior college in Iowa.

Other encouragements to high school students have been the 10 annual symposia on "Science, Technology, and the Humanities", directed by Dr. Pizzini and sponsored by the Science Education Center at the University of Iowa and the U.S. Army. Talented high school science students (typically about 40% girls) and their teachers spent 2 days in Iowa City. Hearing speakers and visiting research labs in areas of interests to "hard science" attracts a higher number of young women to these conferences than their percentage of class enrollments would suggest.

The Secondary Student Training Program at Iowa also provides unique opportunities for gifted high school students to do some research with collaboration and direction of University scientists. Many young women take this opportunity to get firsthand experience in an area of interest before completing high school, and gain confidence in their abilities as they write their reports and as they publicly explain their project and results at a special session of the Iowa Academy of Science, and when they compete for prizes and scholarships in state and national science fairs.

In 1982, another workshop I initiated will provide additional career information to job-seeking trained women in Iowa. Additionally, an extern program is being implemented that will pair a woman who expects to be working within the next year with a woman scientist, engineer, or technician already pursuing a career in the area of interest. The novice will "shadow" the professional for a week to see firsthand what the environment, responsibilities, and special features of the job may be, gaining new perspectives for both hostess and visitor.

The feminist movement has stressed economic independence and parity for women. Thus it is surprising that more women do not aspire to be engineers, geologists, and computer specialists. Those are the "in demand" occupations, followed by industrial chemists. Actually female enrollments in those areas have never been higher, probably due to widespread publicity about the employment opportunities available. Yet most sciene-talented women still flock to biological and pre-medical courses and some medical colleges have 30-35% women students compared to 1-5% accepted 20 years ago.

Increasing opportunities has resulted in an increased response favoring the service-oriented, health-related occupations.

Why haven't the physical scientists similarly benefitted by attracting talented girls? The greater professionalism and appearance of "closed ranks" among physical scientists may make them seem less approachable. In the United States, natural history was still essentially an amateur's pursuit encouraged by local clubs in the 19th century when college education for women first became a possibility. Therefore young women and their mothers had opportunities for developing their interests and enthousiasm for the fauna and flora of the local environment. However, the physical sciences had already passed into professionalism and were much more formidable to approach (Daniels, 1971).

Analogies of sexual aggression - "force", "pressure", "dynamics", "thrust", "implosion", "penetration", "insemination of ideas" - can be interpreted as hostile to women, and they abound in the literature of physical sciences. Mathematical abstractions are often introduced in instruction or even used as explanations before adequate verbal equivalents are elaborated in the classroom, giving impressions of "secret passwords" or a hidden code comprehensible only to an initiated elite. Also, the historical symbiosis of war and technological advancements is wellknown and less than interesting, even repugnant, to many talented women. Emphasis on ballistics, high-powered and mammoth mine strippers, nuclear submarines, neutron bombs, and fusion-applied world-wide power grids may appeal to persons delighting in remote control of large numbers of people and resources. But I think such persons are rare among women. Their life-experience is more closely related to cooperative efforts and to work perceived as socially beneficient. While women who choose careers in science are likely to be more creative, androgynous, and independent thinkers than their peers, they will have preference for more human-scale pursuits like active and passive solar-heated buildings; medically-related engineering projects (over ½ the students in bio-engineering at U. of Iowa are women); environment-related chemistry, biology, and geosciences that have implications for future generations. Some, indeed are into "war games", but I think research will show that they are a distinct and very small minority.

Metaphors of science, then, may need to be given more attention by educators and textbook writers. Some time-worn analogies about projectiles and pistons could be replaced with descriptions of hang-glider paths and hot air balloon mechanics. Molecular dynamics of ions in solution can be introduced with comparisons to behaviour of people in crowds, as Canadian teacher Ton Hodges (1975) has done, or parallels between hockey and chemical kinetics may be drawn. New interests in women's sports can provide associations for explaining natural phenomena.
Tennis ball trajectories may replace talk of bullets and bombs.

The idea that significant numbers of young women *should* be in scientific and technical careers is new to the Western World, just as science education and industrial technology is a new element for the culture of developing countries to absorb. As recently as 30 years ago, when I was in high school, one of my teachers glossed over Marie Curie's contributions with the deprecatory comments that, "Of course, her husband was a *real* scientist" and "She was so dumb about housekeeping that she couldn't even boil spaghetti without burning it." The hostility against her achievements and failure to fill a typical "woman's role" was effectively communicated to young men and women alike.

In summary, then, women have not had access to an infrastructure and "buddy system" of role models of the same sex in scientific careers. At the same time they've been immersed in a culture emphasizing traditional daugher, parent, spouse roles for all its women while industry has automated most of their productive crafts. To counteract this historical development of women as a useful but option-limited, less intellectually adventurous pool of workers and citizens excluded from scientific pursuits, several areas for action, for research, and for development are suggested:

1) New analogies, metaphors, and examples of scientific applications should be emphasized by teachers and texts;
2) Single sex classes or "pooling" of gifted girls in special conferences, science clubs, summer research opportunities and camp experiences should be encouraged;

3) Role models of professionally employed women in scientific and technical careers should be involved in classroom visits, as job-site hosts, as tutors, and as informal counselors/advisors for girls interested in science and mathematics;
4) Development of informal recruiting systems via summer jobs related to technical work; "shadowing" or apprentice experiences on a one-to-one basis; sponsorship of student projects; Career Day information, interviews, and visits involving local industries needing qualified personnel;
5) Encouragement of young women by teachers, counselors, parents, potential employers, and peers to be active seekers of knowledge, to perceive science as an open-ended creative activity that enlarges the human potential and provides new avenues for support and development of life.

Don't deny that science is a counter-cultural activity; for women, it is. Overt recognition of this conflict with traditional culture-conserving roles is a creative challenge. After all, the goal of educators should be not just to throw students a fish for their immediate needs. Nor is teaching students how to fish enough, as the old proverb implies. Rather all students, men and women alike, must encourage each other to restock the pond. Then women will no longer be a developing country. Instead, they will be developing a country and a hospitable world.

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16. Recruitment of Women Scientists

Status and Proposal

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Despite broadly based ifforts to encourage women to enter careers in the sciences and despite an actual small increase in the numbers of women training for and entering them, women continue to lag far behind their male counterparts in both preparation for and entrance into scientific occupations.

In the decade of the 1970's, women earned approximately 28,000 or 15% of the doctorates awarded in science. Of those awarded, a disproportionate number were awarded in the behavioral and social sciences and in the life sciences. The behavioral sciences included in the investigation included psychology, economics, anthropology and sociology, geography, and political science. Women earned approximately 25% of the doctorates awarded there. The life sciences, including biology, zoology, biochemistry, agricultural sciences, health, and medicine, awarded approximately 20% of their doctorates to women. Comparable figures for the awarding of degrees in the physical and mathematical sciences, chemistry, physics, mathematics, computer science, and envirnomental science, and in engineering were 6.6% and 3.5% respectively (Annual Report of the National Academy of Sciences, 1980).

At the bachelor's level of preparation women earned 37% of the degrees awarded in the behavioral and social sciences, 38% of the degrees awarded in the life sciences, 18% of the degrees awarded in the physical sciences and 7% of the degrees awarded in engineering (Annual Report, National Center for Educational Statistics, 1980).

Of those women completing training, some fewer than men entered the job market. At the doctoral level, 96% of the women and 99% of the men found jobs in science in all areas except in engineering where women found jobs more readily than did men and both sexes were employed at the 99% level (Annual Report of the National Academy of Sciences, 1980).

In ability, women seem to be about as able as men to work in the sciences. Macoby and Jacklin (1974) in a classic review of the literature on sex differences concluded that women had some slight edge over men in verbal skills and that men had some consistent superior ability to deal with visual-spatial tasks, but that individual differences among members of each sex was greater in both cases than were the differences between sexes. The commonly observed phenomonon of "math anxiety," fear of not doing well which translates into avoidance behaviors and reduced performance, would appear to be just that--fear.

Once they get into a science oriented career, the women seem to earn close to and in some cases more money than their male colleagues. Specific instances of discrimination in starting salary and promotion do certainly exist, but on the average women earn salaries comparable to those of men at starting levels. Women Ph.D's in 1979 earned something less than $250.00 less than their male colleagues in the physical and mathematical sciences. In the social sciences the figure increased to something around $1500.00 a year at the maximum. In the health sciences the difference increased in favor of the men up to an average of $3,000.00. In engineering, however, women earned on the average $250.00 more per year than did their male colleagues at the entry level (U.S. College Placement Council, 1980).

When these figures are compared with median salary figures for workers in general, women scientists appear to fare even better when compared to male colleagues. Median salaries for women with eight years of public school in 1979 was $6,000.00 a year whereas the median salary for males with eight years of public school was $12,000.00 per year. For those completing 12 years of public school, the figures were $9,000.00 and $15,000.00 respectively. For college graduates at the baccalaureate level the figures were $11,000.00 and $20,000.00 respectively. Those with five and more years college, the figures were $14,000.00 and $22,000.00 (U.S. Dept. Comm. Report).

In all, women college graduates earned 60% of that earned by their male counterparts and close to the amount earned by a male who did not complete the first eight years of public school. This may be accounted for largely in that 2/3 of all women employed were employed in stereotypical female occupations which pay on the whole less than stereotypical male occupations (U.S. Department of Commerce Report, 1980).

Without making brief that female scientists are overpaid or even paid well enough, they can be said to fare better in the sciences than they do in occupations in general. Salary alone is not a reason for women failing to enter the sciences.

Women do, however, stay out of careers in the sciences in substantial numbers. And they do so when they have the ability to compete well in them and when the earn better salaries, find jobs, and get promotions.

Why is it that women avoid careers in the sciences? Well, in the first place they often simply do not think about going into science. They don't know women who have done it. And they see a career there as something a woman wouldn't seek. These, at least, are the things I find when I talk with young women coming to college at my institution each year. The troubling thing is that women say that now even though there has been a press for some time to change attitudes. I might say also that women at my institution are not unusual in expressing these thoughts. We attract a large number of women, in fact, who are interested in science and who come to us because they are interested in science. If our female population is different in any way it is more likely that we have more rather than fewer women students who come with plans to enter science. The majority of them, however do not and seem to me at least to be avoidant rather than neutral in considering science career alternatives.

For some years now psychological researchers have been looking at why it is that rational, intelligent young women avoid professions in general. The avoidance of careers is not limited to careers in the sciences. Here, of course, I am talking about the professional and not the assembly line worker in a scientific organization.

Explanations have included and accounted for variables which impact on women from without and variables which impact from within in the nature of attitudes, beliefs, and values. Data for the first have been nicely reviewed in the educational literature (Ekstrom, 1972; Roby, 1973; Kutner & Brogan, 1976) and suggested as late as the mid 1970's that women continued to be encouraged less than do their male peers to enter training programs and/or to pick up basic skills, that women receive less financial help to get training or schooling. and that they had been counseled at the completion of their programs to accept less demanding (and less financially rewarding) assignments. A more disturbing to me hypothesis for why women fail to enter the sciences emerges from the data from Spence, Helmreich, & Stapp (1975) who suggested that women may be realistic in believing that they are discriminated against for being competent in the ways men are competent and that they would have to become competent in order to enter a professional career in the sciences.

In the Spence, Helmreich, & Stapp study both males and females were given an opportunity to respond to a portrait of a competent person (in a videotape interview) by means of a projective technique (a series of questions about the stimulus person) before answering objective questions about her or him. Males and non-feminist females rated the women as less desirable as a social companion than they did the males though each sex showed the same behaviors. Only female feminists rated the woman to be as desirable as they rated the men on social variables. Hagen and Kahn (1975) presented data supporting the hypothesis that males spoke a language of being willing to accept females who showed professional aggressive behavior but avoided significant interaction with them when given free choice and alternatives of non-competitive women. Both males and females were likely to exclude the women they rated as being competent on career variables when choosing a social group. At the same time they were likely to include in their social group women they rated as incompetent on career variables, suggesting differential reward for the demonstration of "incompetent" work oriented variables.

Shaffer and Wegley (1974) found, further, that devaluation and rejection of women occurred more strongly when competent women openly adopted competitive orientations and minimized nurturing and supportive behaviors. In this investigation male and female college students read descriptions of a highly successful female student who was viewed by her college instructors as having "great potential for a successful career in her chosen field." Two characteristics of this fictitious individual--her degree of success orientation and her preference for masculine or feminine sex roles--were varied. That is, she was presented as havigg been oriented toward success or as not oriented in that direction, and she was presented as having been oriented toward a feminine-nurturing posture or as having been oriented toward a competitive-masculine one. Both male and female students rated the competent woman as having been less attractive as a work partner when she combined strong success orientation with a preference for the competitive-masculine role. Relatively more attractively rated were the women who were portrayed as either strong in success orientation or preferring the competitive-masculine role but not both. The women who had been portrayed as low in success orientation and feminine-nurturing in role preference were rated most attractive as a work partner.

Appleton and Gurwitz (1976) found that both males and females were preferred in terms at least of the amount of time persons were willing to spend "helping" them when they expressed role-expected career preferences. In their study male and female college students sought help from male and female subjects in selecting careers either in engineering or in library science. Measures of the amount of time spent in "helping" the students choose the career included (1) time spend in interviews, (2) time spent in telephone conversations, and (3) time spent in letter writing. On all three measures subjects elected to spend more time with a woman student when she indicated she wanted a career in library science than when she said she wanted one in engineering. In fact behaviors other than strictly career-counseling behaviors were elicited and recorded.

Male students were comparably given more time when they indicated they were considering a career in engineering.

Whatever other interpretation one places upon the data presented, one might conclude that women (and men) find it more difficult to remain conflict-free when entering a non-traditional area and that they do so particularly when that non-traditional area demands behaviors which people generally find attractive only in the other sex. Add to this the competing rewards women find in building relationships outside of work, in establishing a home, and in raising a family, and one begins to see that women need a special kind of encouragement if they are to enter non-traditional areas in general and science in particular. That is, they need access to specialized training and to jobs, but they also need to deal with a rather complex set of realities; and they need something beyond training and job access to deal with those. They need evidence that they can find reward in the larger sense--that they need not necessarily give up rewards in social and feminine-role areas.

What is it that enables a women to achieve success in this larger sense? A study done at the University of Michigan (Tangri, 1972) provides some interesting answers to this question. A wide variety of psychological measures were taken on 200 women students who were enrolled in traditionally male dominated majors. Past and present family relationships were investigated. Contrary to previous research, women who aspired to the male-dominated professions indicated they identified not so much with their fathers as with educated, successful women. That is, they had had successful female models available to them. They were also at least as likely as their peers in the more traditionally female majors to have both romantic and casual relationships with men. What was different, primarily, was their commitment to the career. Secondarily they were found to be more autonomous, more individualistic, and more internally motivated than were the traditionaly oriented women. They also expressed more doubts about their ability to succeed and about their identity.

They found support for their aspirations in the companionship of female friends and instructors. Rated as more important for them, however, was support from a boyfriend, male instructor, or lab assistant. The key,overall, was acceptance and support from people the women students found important to them.

Kundsin (1973) conducted an intensive study of 12 women scientists. To be included in the study, the women had had to be nominated by both male and female peers, they had had to be married and raising a family. The 12 women scientists wrote extensive life histories and were analyzed by experts from a number of fields. In a psychiatric analysis (Anderson, 1973) the variable which emerged as most important in determining their success was an ability to cope emotionally with being reacted to as deviant. Anderson found also that the women were able to function autonomously to an unusual degree and that they were much more able than the average person to function well despite lack of understanding from people around them. Again, family histories showed support for them in general and support for their choices of career in specific. Both male and female models for achievement appear to have been accessible to them. Nine of the fathers and seven of the mothers were reported by the successful women as having been supportive of them and of their choices of career. Only one parent was rated by them as having been negative toward them or their career choices. Half of the women scientists had been first-born children. More than half of them had had only one sibling. As an aside, they had on the average more children than they had had siblings. They all evaluated their marriages as having been satisfying.

What can we learn from these studies about what it is that women need to train for, enter, and maintain a successful career in the sciences? First, women must be able to see and to work with successful women scientists. The importance of a model in making choices emerged as a critical factor. What was not so clear from the studies reported, but is something I have found in 20 years clinical work with young women, is that models are most effective when you also have a language for identifying what is and is not essential in the model's behavior to success in the modeled activity. The studies cited above give us a beginning language. I think, however, that we might improve on this language. Perhaps we can talk a little more here at the completion of the paper about what it takes to be successful. Afterall we have some experience collectively and individually in being successful scientists. I would like to invite us to talk about this. Whatever it takes, I suspect strongly that we will see large numbers of women enter the sciences only if we can make a rational case that one can do what one has to do as a scientist without placing in jeopardy other successes that women need. I would like, also to see us talk about this at the conclusion of the paper. Personal and social support beyond that provided in role-appripriate modeling also emerged as an important variable in the studies cited. I personally believe it may be as important as, perhaps more important than, the other two variables identified. What it is that the support need address will vary from person to person and place to place, but I think it likely it will always deal rather directly with what Tangri's women called self-identity and ability to succeed.

As a practical strategy I would like to suggest that women who are already successful career scientists reach out, and be given opportunity to reach out, to talented women at all ages to let those women who are able but who have not given serious thought to a career in the sciences that it is possible to successfully combine a career there with personal goals. Second, I would like to suggest that we develop and/or improve upon already developed networks for communicating information, defining issues, and providing personal and career support for the already employed scientist, a contrivance to be sure but something approximating the "old-girl" network. Third, I would like to see interaction among women scientists at all stages of the development of careers. Those more experienced coold provide models for those less experienced; those less experienced could model success for those even less experienced and so on. One of the things I have found to be true in my experience in working with women scientists and women students is that someone always teaches someone else something when you put people together who have common interests and a common need to meet. I have found, also, that I can learn from women at all stages of their careers. Those ahead of her provide models for things I would like to do better and those of lesser experience, while sometimes doing that, always seem to pose questions in ways I think anew about my own experience and through that thinking find fresh perspective.

As a side benefit from getting women together, I have found that male colleagues stand watching on the side and on invitation join in the gathering and profit from it. Those I work with at Gustavus tell me they have come to change their ideas about women since I have begun holding workshops for them. They tell me, and their female students confirm their reports, that they are less prejudiced against women than they were before. This didn't just happen. I deliberately brought women scientists in for the first workshop all of whom were superior in credentials by any criteria to the men with whom I worked. I did so, however, in a way that the men felt a part of the endeavor. For example, I collected vitae and then asked the men to advise me on who to bring in. In that sense, the women who came in were there (partially) by their choice. I believe those male scientists have changed their attitudes toward woman students: I see them actively encouraging talented women to plan majors in their departments; and I see some of those women becoming science majors. More detailed information about our plan at Gustavus can be found in an appendix to this paper in the form of the narratives for project proposals submitted to and funded by the National Science Foundation Women in Science Programs, 1977, 1979, and 1981. The keystone of these projects was provision of support for women to enter science. I believe and I present for your consideration here the thesis that what women need to enter programs in science does not differ greatly from what they need to remain in science fields--that the needs of both the novice and the experienced scientist are similar and that they center principally upon development of strategies for filling a complex set of personal and social goals.

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NARRATIVE

A. Description of the Workshop

The Gustavus Adolphus College Science Career Workshop for Women will be held on the campus Saturday, April 24, 1982, and will be accompanied throughout the year by continuing women in science activities. Participants at the one-day workshop will be 75 women scientists from south central Minnesota and surrounding areas who have at least a baccalaureate degree in science and are currently unemployed or underemployed as scientists, and 75 women students who are majoring in a science. Gustavus Adolphus College is a particularly appropriate setting for this Workshop because of its reputation as host of the annual Nobel Conference in Science, because of its successful 1977 and 1979 Women in Science Workshops sponsered by National Science Foundation, because of its leadership in Cooperative Education in Minnesota, and because of its location in south central Minnesota where it can draw participants from the greater Mankato-St.Peter-New Ulm area, Faribault-Owatonna, and the Twin Cities.

The Workshop will consist of: 1) an opening session with a keynote address on the concerns of women in science, including training, career breaks, re-entry, and career opportunities; 2) information sessions conducted by resource persons from both industry and academia; 3) a noon luncheon with several additional resource persons available and with an address by one of them; 4) a closing session with time for evaluation and with a closing panel of resource people; and 5) an information coffee during which participants can become familiar with materials available in the Gustavus Adolphus College Career Resource Library and can also select materials to take with them.

1) Opening session. This will be a time for the brief introduction, followed by a keynote address by one of the eight resource persons. She will present accurate data on how women are being educated and hired in scientific fields, mentioning that career breaks and re-entry are normal stages in the careers of many women in science.

2) Information sessions. When registering for the Workshop, each participant will select three of eight possible information sessions. These will be conducted by menbers of industry and academia who represent a variety of fields including the physical, biological, medical, enviromental, social and behavioral sciences, as well as mathematics and engineering and who represent this state, other regions, and various sectors

of the economy. The resource people will use a lecture/discussion format. The lectures will provide specific information about educational and job opportunities in the particular field and will also describe re-entry programs that already exist for women in science. Lectures will explain what areas within each field are growing and will be sources of employment in the future. They will discuss strategies that employed women scientists have devised for coping with problems unique to women, such as dual career families and child care. Participants will be encouraged to join in a discussion of these topics, immediately beginning to form a basis for networking and mutual support and understanding.

3) Noon luncheon. The luncheon will be an integral part of the Workshop experience since it will function as an additional information and networking session. One of the resource persons will present an address concerned with current research on women in science. The speaker might be someone like Dr. Edith Luchins of the Department of Mathematical Sciences at Rensslaer Polytechnic Institute, Troy, New York, who is conducting research on the psychology of learning mathematics. Discussion at the luncheon will be enriched by the precence of scientists from the greater Mankato-St. Peter area, both men and women, including Gustavus Adolphus faculty members and faculty spouses trained in science, and career and placement counselors, in addition to the eight principal resource people. Seating at the luncheon will be planned to maximize conversation between participants and resource people.

4) Closing session. Participants will reassemble after their final information session to take part in evaluation and to hear a closing panel of both men and women scientists who will summarize what they believe to be the significantissues facing women in science that have been raised during the day. Panel participants will include some or all of the eight resource women, with the addition of male members of the Gustavus Adolphus science and social science faculty.

5) Information coffee. A short information coffee will be used to provide Workshop participants with pamphlets, brochures and other printed materials that they may take with them, including materials offered by resource people whom they have not had the opportunity to hear or meet. These printed materials may deal with a spectrum of topics from science career opportunities with a specific firm to graduate school requirements to resume writing. This coffee will also provide an introduction to kinds

of materials in the Gustavus Adolphus Career Resource Library, which will be an important facet of the Workshop's continuing activity.

Publicity for the Workshop (as well as the continuing activity) will be coordinated through Steven Waldhauser, Director of News and Information at Gustavus Adolphus. He will use standard publicity channels such as area and Twin Cities newspapers, radio and television. In recruiting student participants, he will see that publicity reaches other campuses through their offices of academic administration and the respective natural, physical and social science departmentsat colleges, univeristies, community and junior colleges within a 100-mile radius of St. Peter, Minnesota. In recruiting the re-entry women, in addition to coverage by the news media, a significant part of the publicity effort will extend to alumni offices of educational institutions within a 100-mile radius. Special emphasis will be placed on announcements in alumni periodicals and newsletters. For Gustavus Adolphus itself, for example, notices will be placed in the Alumni Quartely for Fall and Winter 1981-1982 and in class letters (which are distributed regularly) of all graduating classes for the past 25 years.

B. Criteria for Selection of Participants

Places at the Workshop will be reserved for 75 women students who are majoring in a science, 35-40 from colleges in a 100-mile radius and 35-40 from the host college. Another 75 places will be reserved for women who have at least the baccalaureate degree in science and who are either unemployed or perceive themselves as being underemployed.

All applicants must demonstrate their potential to succeed in a science career, presenting as evidence their academic achievement and/or preparedness or past employement. In the case of students, paritcipants will be invited through the Academic Dean's office at each institution. Deans will verify that applicants have at least a B average in science courses and/or an SAT score in the range of M-550. Re-entry women should hold a baccalaureate degree in science from a recognized institution of higher education.

Gustavus Adolphus will invite applicants based first on criteria of potential success in a science career and second on stated need for assistence. In order to encourage racial minority and handicapped women to participate, the latter criteria may be given primary consideration.

C Continuing Activity

The continuing activity for Workshop participants will be incorporated into the Gustavus Adolphus College Career and Life Planning Office and will be directed by Patricia Hamm, Career and Life Planning Coordinator (See Vita, Appendix A). Her position, established at the beginning of Academic Year 1980-81, provides on-campus career couseling and internship referrals for Gustavus students, allows students intereated, in science careers to be identified early in their undergraduate years, and offers support services for them. Incorporating the Women in Science continuing activity into Ms. Hamm's office demonstrates an institutional commitment to providing support and resources for women interested in science careers.

As part of the continuing activity, career counseling will be available through Ms. Hamm's office on a one-to-one basis for each woman participating in the Workshop. The anticipated need will be for those women who have experienced a career break and/or are looking for re-entry skills and information. Services available will be centered in the Career Resource Library and in the areas of career counseling and career networking.

The Career Resource Library next to Ms. Hamm's office will be updated to reflect current information on careers in science as well as material to assist women in life planning, creative problem solving, job seeking, dual career families, career breaks, leadership training and personal development. This material will be available to all women attending the Workshop to help them in exploring career goals with an awareness of the influence of sexism and stereotypic attitudes on their occupational choices. A selected bibliografhy (See Appendix B) lists resource materials already available and a sample of those to be purchases with NSF support. Ms. Hamm will introduce the participants to the library and will explain its use.

Another facet ot the continuing activity directed by Ms. Hamm will also be an expansion of work that is already Ms. Hamm's respnosibility. A network of women scientists will be ciltivated as a strategy for helping women scientists with the re-entry transition. A list of Gustavus alunmae involved in a science career, and who are willing to meet and counsel participants,will be made available to all who attend the Workshop. This list can be extrapolated from a larger list of Gustavus alumni and their careers which has been developed during Fall, 1980. by the Career

Couseling and Cooperative Education Department under a current grant in career preperation and liberal learning from Northwest Foundation, St. Paul. This list will be updated annually to reflect the job placements of each Gustavus graduating class and every two years for the job changes of listed participants. Ms. Hamm will coordinate the networking activity.

It should be noted that Gustavus Adolphus College already supports a continuing activity that results from the 1979 Women in Science Workshop supported by National Science Foundation. Dr. Sylvia Shafto, adjunct academic advisor to women science students regularly counsels women students concerning their academic programs and arranges information/discussion sessions for them. Dr. Shafto's budget is allocated by the College. No funds for her or for her program are requested in the present proposal. The list of women among whom she currently publicizez discussion/information sessions, however, will be expanded to include participants of the 1982 Workshop. Topics covered in these sessions are equally applicable to women science students and trained women who are experiencing a break in their science careers. (See sample list, Appendix C.)

17. GIRLS AND PHYSICS

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THE PROBLEM

Natural science is a "male subject" in Norwegian schools, and physics is the part of science where this is most marked: Girls very early develop negative attitudes to the subject, they underachieve compared with boys, and they avoid physics when curricular choices are made.

On the other hand, the entrance qualifications for many advanced studies are linked to attainment in mathematics and physics. Whether or not a de facto knowledge of classical mechanics is needed to become (or to start studies to become) an engineer, a doctor, a dentist, etc. is not the main point here. (But it is very doubtful indeed!). The important point is that the formal requirements for acceptance are in terms of attainment in mathematics and physics (and not in biology!) These "hard" subjects serve the role of being a selection mechanism, and they have developed a well-protected aura of being "objective" criteria for future educational success.

So, when girls early at school choose not to take physics, they also make negative choices for their later possibilities, often without being aware (or being made aware) of this. And they not only turn their backs on careers as technologists, they often also close the doors on medicine, dentistry, veterenary medicine and a lot of important occupations with high status and income. As a slogan, one could say that "physics today is power tomorrow".

By not taking physics at school, girls restrict their educational and vocational possibilities. And equally important: They leave major fields in society open for male dominance.

THE PROJECT

The project "Girls and Physics" is supported by the Ministry for Church and Education and carried out at the Centre for School Science at Oslo

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University. This Centre is a link between schools and the university. Important activities are to give help and advice to teachers, to run in-service courses, to be involved in curriculum development etc.. To do such work requires a background in the subject-matter, a knowledge about and experience from the school, and some training in educational theory. Hence, the staff at the Centre is composed of people covering these various fields, and together with attached university students they are also involved in research in the area of science education. A description of the various research interests of the Centre is given in (1).

The project "Girls and Physics" has been founded for a period of three years, starting in 1981. A steering group of 6 persons (3 of each sex) is responsible for the project, one of these is employed on full time. In addition, two students are involved in empirical studies that will be the basis for their final university degree (cand. scient).

PERSPECTIVES AND AIMS

The project is clearly action-oriented: Its aim is to help *change* the present situation, to develop strategies that will result in greater equality between the sexes with respect to subject choice and choice of later studies and careers.

We see the need for changes of two kinds:

1. A change in the descisions taken by *girls.*
2. A change in the *subject* and *classroom practice.*

The *first point* may be achieved by giving better and more relevant information and advice. Girls should be made more aware that curricular choices may have large and unwanted consequences for later education and their vocational possibilities. Informational material directed towards the girls may help, and advisers and teachers must also be made aware of the problem. We have examples that both teachers and advisers all too often only strengthen the traditional stereotypes instead of actively counteracting them. Other measures for influencing the girls' decisions are also being considered.

The second point involves a change in the subject and the way it is presented both in books and in classroom activities. Since this point forms part of our ideology, a set of values that we believe in, it may be worthwhile to elaborate this a bit:

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We consider "physics" not to be an unproblematic commodity existing by itself. Out of the wide stock of knowledge of the physical world, some products and some processes are selected as being worthwhile school knowledge. Since physics teachers are men, and since physics textbooks are written by men, it is likely that this influences the selection that is made.

We also consider the implicit image of science presented in textbooks to be an important point. In our opinion the current textbook version of science is a closed and authoritarian activity, where the main point is to reproduce answers to questions you never asked, or to remember the correct formula where you can slot in your numbers only to grind out the correct solution. One can show that this kind of game is played (successfully!) also by university students (2). Part of the textbook image of science is also that of an objective and neutral, "clean" intellectual pursuit isolated from the turmoil of politics, culture, philosophy, production and societal context in general. We will argue that this image is at odds with all current thinking in epistemology and in the philosophy and history of science, but it may be well suited for the selection purposes described earlier.

Also for reasons other than educational equality, we want to change this image. Physics should, in our opinion, be presented more as a process than a product, more as a way of asking and finding out, than a collection of answers to given questions. Physics should also be "humanized", shown to be an integral part of our present culture as well as our past. Physics concerns our world picture, and physical theories have wide philosophical implications. Furthermore, in present society, many important and controversial decisions must be based on scientific knowledge in combination with value judgements. By stressing such aspects of physics, we are sure that pupils with different values and perspectives will find it interesting.

In "humanizing" physics we hope that more girls will find it challenging. We also hope that girls in turn might make a positive contribution to this development.

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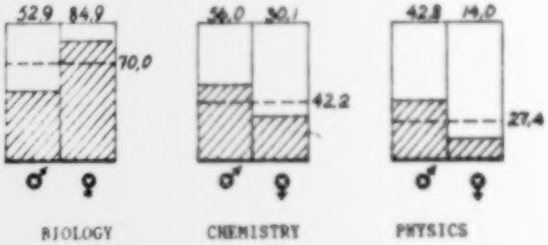
But of course; in addition to determination and ideology, we need factual knowledge about the situation we want to change! And to develop effective strategies, we need to know which factors that are crucial, we need to know where, when and how the problem can be attached.

In the following, we describe some of the results we already have and the kind of investigations we are involved in.

SOME PRELIMINARY RESULTS

Attitudes

In the Norwegian comprehensive 7-16 school, science is taught as one integrated subject the last three years. In an empirical study (3,4), a representative sample of some 2,000 pupils were asked to underline the part of the subject science that they liked best shortly after leaving the 9-year comprehensive school. The results were these:



The relative popularity of science subjects

Numbers on top of the columns give the frequencies for boys and girls separately, and the number to the right gives the total. The sum for the three subjects is more than 100%, since some pupils underlined two of the three sciences that school sciences comprises.

The picture is clear enough: Biology is the most popular part, physics is the least. This applies to both sexes, but while the differences in boys' preferences are rather small, they are extreme for the girls': Dropping from 84.9% liking biology down to 14.0% liking physics. A recent study (5) has shown a similar popularity pattern for the sciences in the Norwegian upper secondary school (17-19 years).

These investigations only rate the different parts of science relative to each other. Let us also look at some numbers where the school subjects are rated relative to other subjects. In a study (6), pupils in the upper part of the comprehensive school (14-16 years) judged science (i.e. the three subjects biology, chemistry and physics taken together) as the only subject at school that could compete in difficulty with the important subjects that have external, written exams. Twice as many girls as boys judge science to be their most difficult subject. (Although the girls' grades in science were slightly better than the boys'!)

When asked which subject they would preferably be spared from, if possible, there were 6 girls to each boy who chose science as the odd one out!

A tentative conclusion is that although biology may be a "girls' subject", it is the hard image of physics mentioned earlier that dominates when science is taught as an integrated subject.

Similar conclusions concerning girls' attitudes to (the different parts of) science are shown in a range of studies in Britain by Ormerod (7). So evidence for saying that physics is a "male" subject is very clear when it comes to pupils' attitudes.

Achievement

The same differences emerges when one looks at actual achievement in tests. Alison Kelly draws the following conclusion in her extensive study of science achievement in 19 countries (8).

> "Within each country fourteen-year -old boys gained higher scores than did fourteen-year-old girls in each branch of science. This despite the fact that in some countries science was compulsory and therefore both boys and girls had studied the same amount of science up to the age of fourteen".

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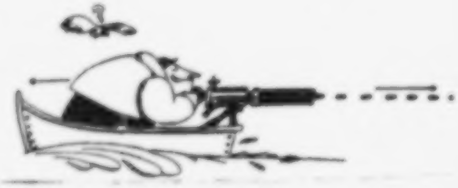
She finds, however, a rather great variation from country to country, and also from one area of science to another. It is interesting, also, that girls in one country may score higher than do boys in another!

In our own studies concerning physics (3,4), we find Norwegian results in line with these. Invariably, boys score significantly ($p \ll 0.001$) better than do girls, although in some cases the difference is great, in other cases rather small. Let us illustrate this point by an extreme example. The problem is the following:

"The drawing shows a man who uses a machine gun instead of an outboard motor. The artist obviously thinks that the boat will move. Do you agree? Give reasons for your answer."



In this particular case, 32% of the (16-year-old) boys gave reasonably satisfactory answers, compared to only 8% of the girls.*

It is tempting to suggest that this huge difference is due to the actual contents of the task: machine guns and motor boats being part of the "boys' reality", but not of the girls'. Or to qualify the statement: It is more probably that boys have had the physical experience of feeling a gun recoil violently against his shoulder, and also that boys in general have been playing more than girls with toy boats as well as with real ones with motors. This difference in background experience is probably one of the stumbling stones for obtaining equality of attainment, and we discuss possible ways for the school to compensate for this.

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* A correct answer could be that a force is exerted by the gun on the bullets, hence the bullets exert the same and opposite force on the gun. Therefore, the boat will move. The speed will depend on the mass of the bullets, their speed, their number, etc. (A wide variation over this theme was accepted).

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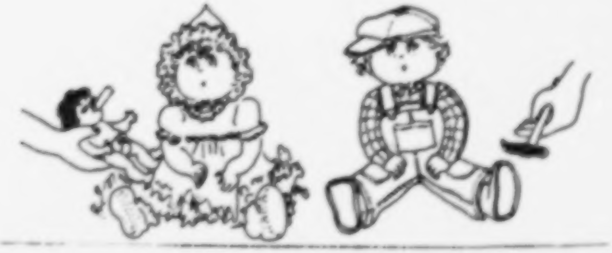
Sex discrimination in textbooks.

Textbooks may favour one sex and handicap the other in many different ways. It is likely that there is an indirect and subtle bias against the girls for many reasons. We will first comment on these.

Most of the socialization takes place outside (and often before) school. The point is well illustrated by the drawing below, taken from a brochure issued by the Equal Status Council of Norway.



It is therefore likely that when boys meet school science, they have already developed manipulative skills; they have experiences of direct relevance for school physics and technology, and they have also developed interests in this area. They also encounter science curricula and textbooks written by men, filled with illustrations and examples based on male experience. And the science teacher is most often a man. This kind of discrimination is seldom the result of a deliberate policy.

It is just "natural" for a male author to choose examples that are drawn from boys' experience (and from earlier textbooks). And besides, although it is easy to say that one should build more on girls' experiences, it is not that easy to be precise and constructive, and to point out exactly what these are. Here, we hope that interested science teachers will generate ideas. (We have already got a wide network of science teachers, mostly women, who want to contribute to the project).

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One can also show that school science, physics in particular, is presented on a level of abstraction that is too high for most pupils (4). Although tests show that girls and boys have the *same* ability (or lack of ability) to handle abstractions, girls seem to be more bothered by not understanding than boys are: Girls feel discomfort when they do no grasp the meaning; boys feel alright as long as they remember the correct answers.

Also, boys seem to be more "instrumental" in their attitude towards the subject, while the "person-oriented" girls seem to be looking more for "relevance", which they do not often find in the hard school sciences (9). School science is "thingoriented", and issues like the social relevance of science are seldom dealt with. The image of science presented in textbooks is in conflict with the values and interests developed by most girls.

These factors: examples based on boys' experience, an unrealistic high level of abstraction, and the hard image of science, are in our opinion, indirect ways of discriminating girls. They also represent areas where immediate action is difficult, but where long-term influence may be fruitful.

In addition to the described indirect ways of discriminating, the textbooks also contain more concrete forms:

Our preliminary analysis of textbook illustrations (10) reveal that out of the number of *persons* depicted, only some 10-20% are girls/women. And *when* they are shown, the message is often of a sexist character: they are shown in a narrow and traditional range of occupations, and often in passive roles. A biology textbook portrays a *man* as the acme of biological evolution, while a naked *woman* is used to illustrate "bilateral symmetry" (one breast on each side of her "symmetry axis"!) The same book also contains clearly sexist cartoons. Such examples are easy to point out, and, we hope, not too difficult to get rid of.

We also cooperate with a research group working on learning difficulties among children from foreign countries. They analyze texts for readability, scientific vocabulary etc. They have registered textbooks from several subjects "on data", which (among many other things) make it possible to get frequencies on certain words. Some results are simple to get at:

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1. The relative frequencies of he/him/his relative to she/her/hers is 97% to 3% in the most commonly used textbooks in physics/chemistry from grade 4 up to 9, all counted together.

2. Many of the "he"s referred to, are named historical scientists. It may therefore be more fair to look at words like boy/man relative to girl/woman. Here the frequencies are83% to 17%.

Comparison with books in history and geography show clearly that the books in physics/chemistry by far are the most extreme!

Such"research": simple counting of male/female pictures and counting of the relative appearance of certain words, is easy to pefform. But even that is important: The results are so overwhelming that they convince those who deny that there is a sexist bias in textbooks today.

For many, these results come as a surprise, since all textbooks in Norway are examined by several consultants before they get the necessary official approval. One of the consultants looks for possible sex discrimination. It was a great surprise when we found out that it was up to the author or publisher to take their advice or criticism seriously or to ignore it. We have taken contact with these consultants, and we plan to take action to see that their comments will be taken seriously. We are also engaged in revising the instructions for these consultants. We also try to formulate positive measures that can make it possible for textbook writers to actively counteract traditional roles. We hope that also publishers will take these matters seriously, and inform their authors.

TWO EMPIRICAL STUDIES

The pupils meet science as a separate subject for the first time at grade 7 (age 14), and we have good reason to believe that this first year is crucial for the development of their attitudes and interests. Our two students are involved in empirical studies concerning this. These studies have just (sept. 1981) started, and short descriptions of the perspectives are given below.

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A. A case study,

where 100 pupils in one school are followed through the year. The student has been a teacher in that school for many years. Through interviews, questionaires and observation he will try to describe what happens in grade 7 and try to identify reasons for this. He will analyze the attitudes, expectations and the factual knowledge the pupils have when they start, and then follow each individual through the year. He will also note whether different subject matter or teaching styles appeal differently to boys and girls.

Preliminary results indicate rather small differences in attitudes to science, as revealed by the initial interviews and questionaires.

B. A national survey

A test and questionaire is being distributed to a representative sample of 1200 pupils from 60 schools all over the country. Several aspects are investigated in this test, some of which have been touched upon earlier in this article.

The pupils are presented with a long list of different topics that might be covered in the physics lessons, and they are asked to indicate what they would like to learn more about. This will give us an interest profile for boys and girls that might be compared with each other and with the actual contents of the textbooks. Included in the list are also topics of "pure" science, different types of technical applications, social issues of science and technology etc.

The pupils are also asked to choose among a list of different learning actvities (doing experiments,reading books, listening to the teacher etc.)

Most of the test is, however, concerned with cognitive aspects of science. In some questions, we ask about basic technical knowledge and specific contents like simple electric circuits, heat etc.. In other questions the pupils are asked to explain rather simple observations from their (different?) daily experience. Another class of questions concern basic cognitive skills of importance to science education: notions of vertical and horizontal,conservation of mass and volume etc..

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Some of the questions are given in two forms: 1) In "closed" form, e.g. multiple choice, where the pupils select among already existing formulations, and 2) in "open" form, where the pupils are free to make their own formulations. The test is administred in two versions, where open and closed questions are mixed so that comparisons will be possible. The hypothesis we have in mind is that different forms of questions might appeal differently to the two sexes. This has been suggested in earlier research.

FUTURE ACTION

In this article, we have mainly described aspects of the problem as we see them, and we have indicated the kind of information we try to produce. Indirectly, we have also described some of the areas where we think action is possible. The main purpose is, as mentioned earlier, to develop strategies for change, and this work is carried out in parallell to the empirical research.

We do understand the dimensions of the problem we face, and have no illusions that we will be able to "put things right". We are, however, convinced that something might be accomplished. And materially speaking, we are in a very favourable position: our Centre for School Science runs a series of in-service courses for teachers. We already use every possible opportunity to raise these problems with the more than 200 science teachers we get in touch with every term.

In cooperation with official bodies working for the equality between the sexes, we are also involved in the development of course material for teachers and advisers as well as information directly aimed towards the girls. We also do our best to stimulate discussion around these problems through articles in teachers' journals and ordinary newspapers. The project has also twice been presented in radio.

We strongly believe that to name a problem, to make it visible and to illustrate and discuss it, is already a move towards a solution.

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18. GIRLS INTO SCIENCE AND TECHNOLOGY: THE FIRST TWO YEARS

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Introduction

Girls into Science and Technology (GIST) is an action research project concerned with schoolgirl under-achievement.[1] Its purpose is to initiate and support school based efforts to improve girls' attitudes to physical science and craft subjects, and to encourage more girls to study these subjects when they become optional. At present technical subjects, physics and to a lesser extent chemistry are dominated by boys from fourth year onwards (Kelly, 1981). This means that girls are cut off from most technical jobs by their lack of qualifications, with deleterious consequences both for themselves and for the country as a whole. It also means that many women are technologically illiterate and therefore at a distinct disadvantage in modern society. Schools will be failing girls if they allow this situation to continue. The GIST project is encouraging schools to take practical action to remedy the situation.

By 'action research' we mean that action and evaluation are proceeding simultaneously. GIST is not a traditional research project where the design is thought out at the beginning by the research team, implemented in a carefully controlled way in the schools and finally evaluated. On the contrary many of the interventions will arise from teachers ideas developed during the course of the project. The research design is fluid and constantly changing. If something does not seem to be working it is dropped. Conversely we are prepared to capitalize on any fortuitously presented opportunity. Many variables are changing at once. This is not a neat experimental situation, but it does approximate to everyday life in a school. We hope to show that, under normal school conditions, teachers can bring about changes in girls' attitudes and achievements. Our main outcome measure is the proportion of girls choosing to study physical science and technology in fourth year in the action schools; if this proportion increases, relative to the control schools, we shall have succeeded.

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[1] The project is based at Manchester Polytechnic and is jointly funded by the Equal Opportunities Commission and the Social Science Research Council with additional grants from the Department of Industry and Schools Council.

Ten co-educational comprehensive schools in Greater Manchester are involved in the GIST project. Two of these are control schools, where attitude and achievement tests are being completed but no intervention is taking place. Although not a random sample, the schools serve a wide variety of socio-economic catchment areas. We decided to restrict the project to co-educational comprehensive schools because the majority of school children in the country are in such schools, and because previous research has shown that the problem of girls under-achievement in science may be most serious there (Harding, 1981). Moreover ten schools is too few to introduce additional variables such as single-sex or selective education. We are mainly interested in the group of children, some 2,000 in all,who entered these ten schools in September 1981. This cohort is being followed from their entry to secondary education at age eleven until the end of their third year in July 1983.

We have chosen to concentrate on these first three years of secondary school for several reasons. At the end of third year, when the children are fourteen, they usually have to choose their subjects for O level or CSE. If they drop physical science or technology at this time it is difficult if not impossible to take it up again later on. Yet previous research has shown that girls' attitudes to science frequently decline sharply over these first three years. (Brown & Davies, 1973; Goodwin, *et al*, 1981) By intervening at this stage we hope to arrest this decline and encourage more girls to continue physical science and technology into fourth and fifth year.

It is frequently suggested that it is too late to do much by the time the girls get to secondary school, and that we should really be working with parents or primary school teachers. While not denying the importance of these other influences we think this is unduly pessimistic. We do not want to write children off as beyond redemption at the age of eleven! Most pupils now coming into secondary school have had little or no formal science or technology teaching, and this new experience must surely have a strong influence on them. On a practical level we feel that our very limited resources can be most effectively used in working with a group of professional science and craft teachers in secondary schools, many of whom are already aware of and worried about girls' under-achievement in their subject.

The GIST project is funded for four years. The first year was preparatory, and was spent recruiting the schools, making contact with local employers to ensure that they would accept girls in technical jobs, piloting our attitude and achievement tests and recruiting women for the VISTA programme (see below). We have now completed one intervention year in the schools, with two more to go. We have already learned a lot and at this half-way stage in the project it seemed appropriate to share our insights and invite feedback from people not directly involved. Our work so far has been concentrated in three main areas: raising teachers' awareness of girls under-achievement and helping them to realize that they can do something about it; initial testing of children's attitudes and knowledge in science and techaology for comparison with their later performance and choice; and arranging a series of visits to schools by women working in scientific and technological jobs who could act as role models for the girls. These are described in turn below.

Working with Teachers

The success or failure of the GIST project will largely depend on the attitude and response of teachers in the action schools. From the beginning we have recognised that intervention strategies are more likely to work if the teachers believe them to be effective and, preferably, have chosen them themselves. We do not expect teachers to solve the problem of girls' under-achievement as seen from the researcher's perspective, but to take up questions of interest to themselves as professionals, with the GIST team in a supportive role.

Ideally, awareness of girls' under-representation in physical science and technical subjects would be a focus of spontaneously occurring discussions among staff in schools. In practice, patterns of sex difference in classroom behaviour, subject choice and academic achievement are frequently accepted as a customary and unquestioned feature of school life. We therefore had to stimulate the sort of discussion which would lead teachers to recognise sex-stereotyping as an educational problem, capable of being tackled in the school context. This is not to say that every teacher would come to view the problem in the same way. But some questioning of the existing patterns was necessary so that the strategies adopted would be in line with teachers' own perceptions and definitions of the problem.

Our approach to potential action schools stressed that all teachers, including the most junior (who frequently carry the main responsibility for teaching younger pupils) should be involved right from the start. Rather than merely negotiating with the head teacher or head of science/crafts, we asked each school we approached if we could talk to the whole department about our plans. At these meetings we presented some information on the extent of girls' under-achievement in science/technology and briefly described the theories put forward to account for the situation. We described some of the strategies which had been suggested to counter this situation, emphasising that it would be up to the teachers to decide which strategies they implimented if they decided to take part in the project. We then left the staff to discuss our proposals among themselves and let us know over the next week or so whether they wanted to be involved.

In fact none of the schools where we gave this preliminary talk turned us down. All agreed to the next stage, a series of three two-hour workshop meetings where science and craft teachers would meet with the GIST team to discuss the 'problems' of getting girls into science and technology, and develop their own ideas for intervention strategies suitable for their school. The commitment of staff was mixed. In some cases we felt the decision to go ahead had been carried by the obvious enthusiasm of senior staff and that some teachers remained sceptical. It was not always easy to overcome a tendency for GIST to be cast in the role of outside researchers proffering solutions. The sessions were held in school time so as to give staff the opportunity to voice their doubts and discuss their reactions in a relaxed atmosphere. And by meeting on teachers' home ground, we hoped to underline the importance of their own expertise in designing interventions.

Previous work with student teachers and on in-service training courses had convinced us that, as professionals, most teachers are genuinely interested in fostering the development of all their pupils and so resent any suggestion that they treat either sex unfairly. At the same time they are prepared to voice highly stereotyped opinions about the behaviour and abilities of girls and boys. Sex differences are often felt to be natural and unchangeable, in line with their own self-concepts as a man or woman, father or mother, son or daughter. Because of this contradiction between a professional commitment to equality and a personal belief in the natural inequality of the sexes, the workshops had two main elements. We provided a good deal of information about sex differences in the classroom, and the research that has been done into the origins of these differences. We also used a number of games and exercises designed to make people conscious of their own sex-stereotypes and of the way social roles and expectations operate in the classroom. The final session was devoted to detailed planning of interventions for that particular school.

In general this combination worked quite well, but there were occasional problems. Some schools found it difficult to get all the relevant members of staff together and we were faced with a different group of teachers at each meeting. In one or two cases there have been such large staff changes that few if any of the teachers who attended the workshops are still teaching lower school science. Some groups were impatient with the 'airy-fairy' theorizing and de-stereotyping exercises and wanted to get on to concrete proposals. It was noticeable that science and technical staff tended to value research based factual knowledge highly and were frequently suspicious of psychological or sociological theories about behaviour. However, when pastoral staff who often taught English or Humanities were present, their response to 'de-stereotyping' discussions was much more enthusiastic. We also had the impression that younger female science teachers were less likely to dismiss personal experience as irrelevant than older male scientists. There was some concern that boys might be disadvantaged by our interventions and we found it important to stress that all we wanted was a fair distribution of examples, teaching strategies, role models, etc. between the sexes, rather than the present over-emphasis on boys.

As a follow-up to the workshops, broader staff meetings were held in action schools with representatives from all departments. The point to be made here was that sex-role stereotyping pervades all aspects of

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life, and that notions such as 'science is for boys' or 'girls can't be engineers' are not exclusively picked up in science and craft departments. Expressions of support for what we were saying about informal learning or the 'hidden curriculum' then helped to create an atmosphere in the school of general belief in the value of trying to change children's sex-typed attitudes and choices. In such an atmosphere, science and craft teachers can receive constant support for their efforts from staff with other subject backgrounds. Moreover since the large staff meetings were arranged with the help of the schools' senior management they signify that the idea of positive intervention has received an official seal of approval.

The extent to which schools have implemented the interventions we suggested varies considerably. Some teachers have realized the importance of classroom interaction and have begun to make small but significant changes in their classroom management techniques. We are now trying to establish a scheme whereby teachers can monitor interactions in their own and others' classrooms. Others have merely accepted the offer of VISTA visits and agreed to administer attitude and achievement tests (see below). Teachers willingness to commit themselves further seems to depend to some extent, on how much time we can spend with them. With a small research team (one full-time and two part-time researchers) special efforts have to be made to visit schools frequently enough for a relationship of mutual trust to develop. In the remaining two years of the project we will continue to work closely with teachers and we hope to reach the stage where every school is using a unique set of strategies developed by teachers for the children and environment they know, which is capable of running quite independently of GIST.

Attitude and Achievement Testing

Our major presence in the schools during the pupils' first term was as piles of questionnaires and brown envelopes. In the preparatory year we had developed a number of tests designed to measure the children's attitudes towards science and technology, their preliminary knowledge of these subjects and their attitudes towards sex roles. Since most of these tests had no right or wrong answers they were generally enjoyed by the children. The results will be used to assess the effectiveness of the interventions. We intend to test the children again in their third year and compare the change in attitudes and achievements in control and action schools. We also hope to be able to see which groups of girls have responded best to the interventions - for example, girls with positive initial attitudes to science or weak sex-stereotypes might be more receptive than girls who are less well motivated initially or more strongly stereotyped.

The tests are also an intervention strategy in their own right. We suggested to the action schools (but not the control schools) that they might discuss each test with the children after they had completed the schedules. In practice this was seldom done. Now that the data have been analysed we are taking the results back to the schools and again suggesting that they be discussed with the children concerned. It is generally easiest to do this in English or Social Studies classes where sex-stereotyping can be examined. But pupil's attitudes to science and crafts, and the reasons for any sex differences found, can also form the basis of a discussion. We have prepared a booklet explaining what we have found and the possible implications of these results, which we are distributing to all teachers involved in the project.[2] And we are visiting each action school to explain what was found in that particular institution (although to maintain confidentiality we are not giving teachers any information

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[2] Copies are available from GIST,(please send a large s.a.e.). A more detailed statistical analysis is in preparation, and will be published in an educational research journal as soon as possible.

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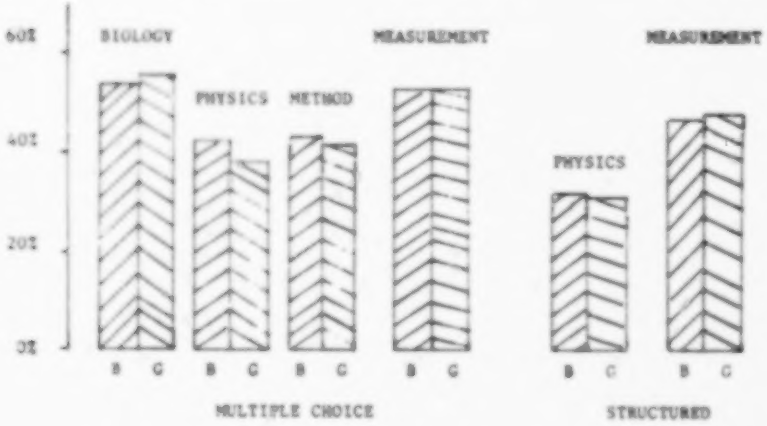
on individual pupils).

During the first week of the first term the children were given two science tests, to assess the knowledge and attitudes which they brought with them to the secondary school. The differences between the sexes in science knowledge were very small (see Figure 1). Boys did slightly better than girls on the physics items, particularly when they were written in multiple choice form but other sex differences were negligible.[3] The most striking differentiation came on the essay part of the test, where children had a choice of subjects to write about. Most of the boys chose 'how cars work' or 'rockets and space travel', but these topics were very unpopular with the girls. Girls predominantly chose 'the human body', 'birds near my home', 'seeds', or 'pond life'.

Figure 1. Boys and girls mean scores on different parts of the Science Knowledge test.



This suggests that sex differences in interests among 11-12 year olds are much stronger than sex differences in knowledge, and this was borne out by the attitude scales. One of these asked the children to indicate which scientific topics they would like to learn more about and which they were not interested in. Most of the pupils were interested in most bits of science, but there were quite marked sex differences (see Figure 2). Boys were much more interested than girls in learning about physical science, and girls were much more interested than boys in learning about animals and plants. The most popular topic overall was human biology, followed by 'spectacular' or 'T.V.' science. We are therefore suggesting to schools that one way to interest both girls and boys in physical science might be to approach it through its links with the human body (e.g. forces via muscles, light via eyes, air pressure via lungs), so emphasizing its relevance to ourselves. However, our results suggest that attempts to interest girls in physics via its domestic applications would not be so successful. Neither girls nor boys were very enthusiastic about learning 'how a vacuum cleaner works' and girls were even less interested than boys!

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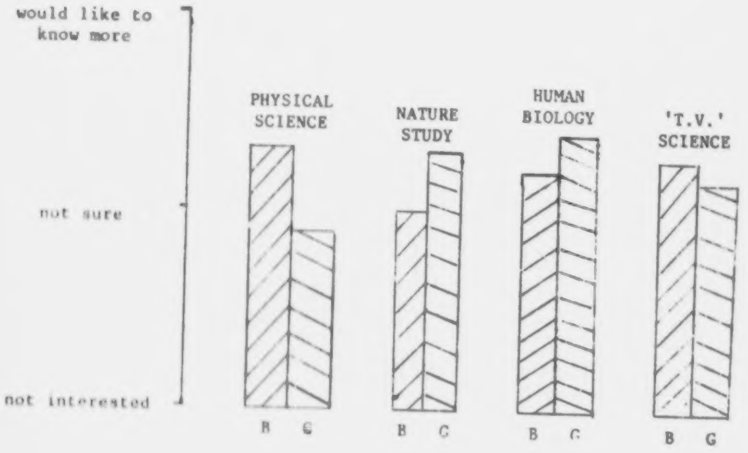
[3] No importance should be attached to differences between the various parts of the test which merely reflect the ease or difficulty of the questions.

Figure 2. Boys and girls mean scores on different parts of the Science Curiosity test.



It is generally assumed that boys have greater experience in technical matters outside school than do girls, but this has seldom been investigated. However, one of our tests asked children about the sort of activities they participated in outside school which might develop skills and knowledge relevant to science and technology. As expected we found that boys had a lot more experience of tinkering activities - using tools, taking things apart and mending them, playing with constructional toys - and girls had a lot more biological experience of things like planting seeds, watching birds and collecting flowers.

The importance of tinkering experience, particularly for technical subjects, is evident from the result of two other cognitive tests. There was a mechanical reasoning test, with questions on gears, pulleys, screws, etc. And a spatial test involving the ability to visualize and mentally manipulate objects in three dimensions. On both of these boys did better than girls. In this context a natural experiment in one of the schools is interesting. Because of the way the craft 'circus' in the first year was organised there, some children spent twelve weeks on technical crafts while others spent the same twelve weeks on domestic crafts. Both groups completed the spatial and mechanical tests before and after these twelve week periods. The group that had been doing technical crafts for the intervening weeks improved their scores on the spatial test significantly more than the group which had been doing domestic crafts. This suggests that boys greater prior experience in technical matters outside school may have caused their better initial scores on this test.

Another of our tests looked at the image of science and scientists held by these pupils. Overall both girls and boys had quite favourable impressions. They thought the social effects of science were mainly good, that scientists were quite normal people and that they themselves would enjoy learning science. But boys were far more likely than girls to see science as a masculine subject. Girls mostly disagreed with statements such as 'girls who want to do science are a bit peculiar' or 'girls don't need to know about electricity and light', but boys were much more likely to agree or be unsure. Boys who think like this probably transmit their attitudes to the girls and make them feel out of place in the science laboratory. So it is as important to work with boys in changing the masculine image of science as it is to work with girls.

Our tests included several measures of sex-typing, and they all showed much the same thing. Boys are more strongly sex-typed than girls at age eleven. They have more definite ideas about what boys should do and what girls should do. In general the pressures on boys seem to be stronger than those on girls - it is worse for a boy to be a sissy than for a girl to be a tomboy - and the strongest disapproval was reserved for feminine behaviour in boys. This again emphasises the importance of working with boys to relax their stereotypes rather than concentrating all our efforts on girls.

We also examined the children's attitudes to school, their home background and their parents attitudes. Although these questionnaires have not yet been fully analysed, they have revealed some interesting trends. More girls than boys in first year named maths as their favourite subject, and nearly as many girls as boys named science. However boys were much more likely than girls to give technical crafts. Girls were more enthusiastic about school than boys were and seemed to be quite confident of their own abilities. Both girls and boys tended to value their own sex and rather despise the opposite sex. Parents were just as ambitious for their daughters and their sons to do well in school and equally keen for all their children to study science (including physics). Contrary to what some teachers believe, the vast majority of parents were happy with mixed craft 'taster' courses. But they were not so sure about children pursuing non-traditional craft options after third year and seemed to expect very different things of their daughters and sons out of school. Parents had quite traditional occupational aspirations for their children, and they expected girls to do a lot more housework than boys.

The VISTA programme

The chief intervention strategy in the first year was the VISTA programme, a series of visits to schools by women working as scientists or technologists. The aim of the visits was to provide the children with role models of women working in 'masculine' occupations who enjoyed their work and were successful at it. Ideally they should have an attractive and vivacious personality and be leading active personal and family lives. In this way we hoped to counter the image of the woman scientists as an oddity and reassure the girls that studying science did not mean abandoning all their existing dreams of adult life. We also wanted to destereotype the remote impersonal image of science and technology by stressing the links between the work the VISTA visitors were doing and what the children were learning in class.

Women were recruited for the programme by advertisements in the national press, visits to local industry, the "Women in Manual Trades" group and personal contacts. Some 90 - 100 volunteers were obtained and they were invited to an afternoon briefing session in groups of 8 - 10. The letter of invitation asked each woman to think about some aspect of her work which could be linked to the science and crafts curriculum in the lower secondary school and to prepare a talk lasting a few minutes to perform at the meeting. An American project similar to VISTA found that girls were particularly interested in ways of combining paid work with family life, but were often shy about discussing this with boys present (Weiss *et al*, 1978) so we encouraged the women to build this aspect into their talks.

About 50 women attended briefing meetings. During the afternoon we tried to give the women information about the GIST project, its progress so far, and the aims of the VISTA intervention. The majority of women responded warmly and gave accounts of their personal experience at this stage. Next we tried to give the women a picture of the 11 year olds they would be talking to in terms of their interests, language level and their image of science and scientists. In doing this we used some essays written by 11 year olds in the GIST pilot study, on the theme of an interview with a famous woman scientist. The essays were effective in revealing both the stereotyped ideas of the children about women scientists and the vast difference between the language level of a typical first year and that of an adult as evidenced by the handwriting, spelling, grammar and sentence construction of the essays. In one briefing we used a videotyped classroom discussion on sex stereotyping with a mixed class of 11 year olds but this was not so successful.

Each woman was then invited to give a short extract from her talk in front of the group and a television camera. It was explained that this micro-teaching was a confidence-building technique often used in teacher training. Each talk was replayed and discussed, pointing out as sensitively as we could, the good things to build on. The women were generally sufficiently aware to pick out for themselves the parts which would not work with the 11 year olds we had described. The final stage of the briefing was to discuss with each woman the parts of her job we thought would be particularly interesting to children and to think of ways to link the talks with topics on the science and crafts syllabus. Each woman left with a number of ideas which could be developed and promised to send us a short paragraph about her revised talk. Some

25 - 30 paragraphs were received.

In January 1981 these women began visiting schools. Visits are arranged to fit in with the work the children are doing in class and take place in normal science or craft lessons. Over 30 visits have been arranged so far, and each women has seen 3 or 4 first year classes for half-an-hour each in the course of a morning or afternoon. They are usually accompanied by a member of the GIST team so that we can provide the woman with some feedback on how their talk went and how it could be improved.

A few examples will illustrate the type of topics that have been covered and the links with the pupils normal school work. When children are working on forces we have a lecturer in anatomy who can talk about the forces in the human arm. When they are learning about acids and alkalis there is a food technologist who brings cakes made from cake mixes with incorrectly balanced baking powder to show the use of pH measurements in the food industry. Learning to use a thermometer is linked to a gas engineer who talks about the different ways of measuring temperature she uses in her work, including a demonstration of heat-sensitive crayons. In craft there is a supervisor in a small brass-foundry who brings rough castings of brass "tortoise" doorstops and other decorative articles and demonstrates the finishing processes used.

The response to the talks by the teachers and children has been quite positive. Some teachers complain that, despite our efforts, the language used by the women is still too difficult. Most of the women have improved their performance in this respect after meeting their first class. The impact of the talks on the children seems to increase as they become familiar with the situation. Some classes have had visits by 3 different women and during the third session questions showed that the children were understanding the underlying purpose and implications of the visits, e.g. children asked about the attitudes of male colleagues and family members. In some groups the boys have dominated the questioning and we have had to coach the women in strategies for getting girls to participate too. The numbers of each sex in the group and whether a girl or boy asks the first question seem to have an effect on the girls in the group. The level of interest and participation of the teacher also seems to have an effect. The teacher can often put into words something which she knows would interest or puzzle the children and this can produce follow-up questions from the class which they may have been reluctant to voice without the teachers' support. Our main problem has been recruiting women technicians and crafts-people doing jobs requiring only CSE or O level qualifications. Not only are there fewer women working in trades than in professional jobs, but they are less likely to be able to get time off with pay to take part in the VISTA programme, and less likely to have the verbal skills and self-confidence to face a school class.[4]

The Next Two Years

Work with teachers, analysis of the test results and the VISTA programme will all continue over the next two years. In addition we hope to develop interventions in three other main areas: crafts, curriculum and careers.

So far most of our work has been in science. This is largely due to our own backgrounds in science teaching and ignorance of craft and technology. However we have now appointed a former head of department in craft, design technology to work with craft departments. His main task will be to develop CDT syllabuses which appeal to both sexes equally to replace traditional skills-based education in woodwork and metalwork which has little attraction for girls.

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[4] Volunteers are still being recruited. If you know of any women who would be willing to help, please ask them to contact us.

We have always seen curriculum development as one of our major concerns. Several pieces of research have shown the way in which science textbooks are biased towards boys in terms of their illustrations and examples (see e.g. Walford, 1980). However we believe the problem goes deeper than this. The way that science is approached as an abstract, ahistorical, impersonal subject may fit boys' interests better than girls'. Beginning with electricity, a topic which often seems particularly unattractive to girls, we want to try to develop some alternative approaches. We have already set up a teachers' group to work on this, in cooperation with the Girls and Physical Science group of the Association for Science Education. But it is difficult for practising teachers to find time to work out materials in detail. So far we have only been able to respond to teachers' requests for materials on a particular topic but in future we hope to be able to devote more time to systematic curriculum development.

As the pupils enter third year and approach their option choices, careers advice will become increasingly important. It has already been shown that girls can be encouraged to study physics if its career implications are clearly spelt out (Hearn, 1980; Patterson, 1980). We hope to develop this approach to include technical subjects. In addition to film and tape-slide shows, the VISTA visits will be slanted more towards careers advice and less towards lesson content in third year. We also hope to arrange individual counselling of girls who have shown scientific or technical aptitude, and consultations with their parents.

This list of interventions is by no means exhaustive. We are cooperating with the Equal Opportunities Commission to produce a series of posters about women's achievements in science and we have developed some worksheets on this topic. We arrange occasional conferences with outside speakers to provide an intellectual stimulus for the project. Several teachers are planning to implement girls'-only clubs in science or technology where girls can gain confidence in handling tools away from any possible ridicule from the boys. This can be seen as compensating for boys' greater experience with tinkering activities outside school. And the list is not definitive. Ideas are coming forward all the time and the next two years may turn out quite differently from the way we currently envisage them.

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19. Differences in practical skills between boys and girls

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1.

In the Netherlands laboratory-based practical examinations in Physics are required in the last year of the secondary schoolcourse from now (for the first time: course 1981/82). It is the duty and responsibility of the school to arrange these examinations well on his own way.
On many schools till now there was developing a debate about the role of laboratory work, there was a grow in laboratory activities and there were experiments in testing practical skills.
Past years I made, together with five secondary schools some kinds of practical examinations in Physics. These examinations are used by the teachers on the schools. The results of the students (age 16, 17 or 18) on these tests have been evaluated with statistical analyse methods.
The aims of the research studies are

- to find methods for making practical examinations
- to find methods for testing individual practical skills
- to recognize the practical skills in the results of students on the various practical examinations
- to distinguish these skills from those used in non-practical work such as written paper and pencil tests
- to start a discussion about the role of laboratory work in physics in the last years of the secondary schoolcourse
- to examine the goals for laboratory instruction in physics education in connection with the preceding points.

The last practical examination was in the schoolcourse 1980/81. I gathered the results of the students on lower parts of the tests and also on some final examination subjects apart for boys and girls. Therefore it is possible to compare the results of the boys with those of the girls. All examined students are in pre-university education (in England to compare with A-level).
The entire population (229 boys and girls) had an option for Physics. The choice for Mathematics I and Dutch then is obligatory. The choice for Mathematics II, Chemistry and Biology is free. The population with an option for Physics on the five schools was composed of 151 boys and 78 girls. Dutch statistics show that less girls participate in physics education than boys (see: Ilja Mottier and Jan H. Raat in Marie, word wijzer ... van Natuurkunde with a summary in English).

In the following table you can see the final examination results (range 1-10) for some subjects consisting of a school-examination (SE) during the last year of the schoolcourse and a central written examination (CE), directed by the Ministry of Education.

Table 1: Final examination results

subject	population		mean SE	mean CE
Physics	total	229	6.32	6.00
	girls	78	6.00	5.63
	boys	151	6.47	6.19
Mathematics I	total	229	6.79	6.22
	girls	78	6.87	6.26
	boys	151	6.74	6.20
Dutch	total	229	6.73	6.45
	girls	78	7.14	6.71
	boys	151	6.53	6.32
Chemistry	total	197	6.46	6.90
	girls	63	6.33	6.68
	boys	134	6.52	7.01
Biology	total	168	6.93	6.65
	girls	65	6.68	6.66
	boys	103	7.09	6.64
Mathematics II	total	63	6.93	6.70
	girls	9	6.89	7.06
	boys	54	6.94	6.64

Discussion:

1. The results on Physics are low in comparison with the results on other subjects. Also other research studies show that Physics is very difficult for the students in the Netherlands.
2. In most cases the results for the school-examination are better than the results for the central written examination except for Chemistry (it was an easy central examination) and the girls for Math. II (no conclusions: to little data).
3. The results of boys on Physics are better than the results of girls; also on Biology SE; the lower measure on Chemistry. The situation is just the reverse for Dutch. There is no (great) difference for Mathematics and Biology CE.

In connection with a physical experiment we can distinguish four groups of practical objectives with many abilities or skills (about 100).

- the road to the experiment with the abilities to comprehend the purpose, to plan, to obtain a viable experimental set up, etc.
- the performance of the experiment with the skills manipulation, observation, recording etc.
- the working out of the experiment with the abilities to arrange the data in tabular, diagramatic or grafical form, etc.
- the conclusions of the experiment with the abilities to draw conclusions, to write a concise effective report, etc.

In table 2 you can find the scores by the students on the various lower parts of the practical examination (four tests; A, B, C and D). There are missing cases.

Table 2: scores on the practical examination

test	abilities or skills	max. score	mean score total popul.	mean score girls	mean score boys
A,B C,D			N = 170 N = 190	N = 60 N = 65	N = 110 N = 125
A	to gather experimental data in a table	7	5.68	5.55	5.76
	calculation with a formula and comparison with data	5	2.87	3.02	2.79
	to make a hypothesis from the data	7	2.02	1.49	2.31
B	to implement procedures and to gather exp. data in a table	11	7.93	7.63	8.08
	to arrange data in grafical form	6	2.96	3.25	2.81
	to interpret results and draw conclusions	7	1.84	1.82	1.85

C	to obtain a exp. set-up and to use materials	5	3.77	3.54	3.90
	to implement procedures and to gather exp. data in a table	7	5.53	5.32	5.63
	to interpret results and draw conclusions	11	3.38	2.88	3.66
D	to obtain a exp. set-up and to use materials	3	2.37	2.18	2.47
	to implement procedures and to gather exp. data in a table	8	5.78	5.38	5.98
	to make and interpret a graph	6	3.46	3.03	3.67
	to interpret results and draw conclusions	8	2.84	2.55	2.98

Discussion:

1. The scores on the abilities or skills to obtain a exp. set-up, to use materials to implement procedures and to gather exp. data in a table are high.
2. The scores on abilities to make a hypothesis from the data, to interpret results and draw conclusions are low.
3. In both cases boys have better results than girls.
4. In two cases girls are better than boys: calculation with a (simple) formula and grafical form.
   It is to work conscientious with data.

It is still too early for conclusions (if possible). I have to evaluate the results of the students further. I hope to show more at the conference.

2.

I measured the correlation between the lower parts of the tests (see Paper 19). Sometimes there was a low positive correlation, mostly when the parts were successive. In many other cases there was zero correlation.

I examined also the correlation between the lower parts of the tests and the final examination results. The correlation with the school-examination Physics was significant positive better than the correlation with the central written examination. With final examination results of other subjects there was sometimes positive correlation and sometimes zero correlation. Between the mutual final examination results of the subjects the correlation mostly was positive. There were sometimes differences between boys and girls but I can't explain.

Also with other statistical methods (canonical correlation and factor analysis) I found sometimes small differences between boys and girls but I can't give conclusions.

In cooperation with another school I gathered the final examination results and the scores on three short practical tests. The students were in another type of secondary general education, havo, in England to compare with O-level. The entire population (39 boys and 15 girls) had an option for Physics. The choice for Mathematics and Dutch is obligatory. The choice for Chemistry and Biology is free.

TABLE 3: Final examination results (havo)

subject	population		mean SE	mean CE
Physics	total	54	6,47	5,91
	girls	15	6,45	5,57
	boys	39	6,48	6,05
Mathematics	total	54	6,68	6,30
	girls	15	6,99	7,01
	boys	39	6,56	6,02
Dutch	total	54	6,64	6,35
	girls	15	7,05	6,42
	boys	39	6,49	6,32
Chemistry	total	41	6,67	7,31
	girls	[illegible]	6,95	7,65
	boys	11	6,58	7,20
Biology	total	37	6,75	6,88
	girls	23	7,11	6,93
	boys	14	6,53	6,86

Discussion

1. The results on Physics are low again in comparison with the results on other subjects.
2. In most cases the results for the school-examination are better than the results for the central written examination.
3. It seems a very good group of girls because the girls mostly are much better than boys.
4. Nevertheless in Physics the boys are better than girls.

The short practical tests were individual. The goal of the three experiments was to examine students skills in reference to measuring-instruments.

Each test (duration five minutes) had a number of three written instructions. While the student was busy experimenting, the teacher was judging him by his actions. On a list the teacher was recording the results of this actions.

For each test there was one teacher available and all students passed him. In the three tests we can distinguish 6 groups of practical skills.

1. to make a diagram of a electrical network
2. to manipulate basic apparatus, switch on apparatus
3. to check apparatus, operation of apparatus, zero-adjustment
4. to make accurate quantitative observations with the choice of scale and the interpolation: measurement of a quantity
5. to record accurately the experimental data obtained with the just number of decimals
6. to record the data with good units.

TABLE 4 : Scores on the tests

skills	max. score	mean score total popul. N = 54	mean score girls N = 15	mean score boys N = 39
1.making a diagram	6	4.130	4.400	4.026
2.manipulating	5	4.019	4.133	3.974
3.checking	5	2.352	2.000	2.487
4.measurement	9	6.074	5.933	6.128
5.recording accurately	6	3.185	2.667	3.385
6.good units	5	3.889	3.533	4.026
total score	36	23.649	22.666	24.026

Discussion

1. The total score on the three tests is good and also the scores on the skills except checking and for the girls recording accurately.
2. On the three tests and on most skills boys have better results than girls.

I measured the correlation between the groups of practical skills. Mostly there was zero correlation. I also measured the correlation between the six groups of practical skills and the final examination results of Physics. Sometimes there was a low positive correlation, mostly there was zero correlation.
No canonical correlation is found between the various groups of practical skills and the two final examination results for Physics.
I have the tentative conclusion that **a zero correlation exists** between laboratory-based practical examinations especially observation, manipulation and recording skills and written tests:
It means that this sort of practical examination gives students fresh courage for good scores independent on the results till now. Its the same for boys and girls.

20. Case - study of the pendulum - experiment

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1. Introduction

In the (rather small) Department of Physics Teacher Training of the Eindhoven University of Technology (THE) we did some case - studies with 8 groups of 2 students for the MENT - project (Raat, Jan H. Intervention strategies in favour of girls achievement in science (physics) and technology in the MENT - project, see paper 13)

By these studies we wan't prove hypotheses. What we like to do with the studies is firstly to have some introductions in the field of the MENT - project and secondly, to do first steps in making material for discussions with teachers.

2. The experimental groups and the experiment itself

We invited 16 students in the age of 13 and 14 years (second year of secondary schools), to do an easy experiment. While doing this experiment we recorded their actions by video - tape.
On a table were put a weight, a support, a string, a stopwatch and a measuring - ribbon.
The instructions we gave the students were:

1. Fasten the weight at the string
2. Fasten the string at the support
3. Let pendulate the weight
4. Measure the time of 10 pendulations
   Do you know how works a stopwatch?
5. What is the time of 1 pendulation?
6. Measure the lenght of the pendulum.
7. Write both results on the blackboard.

The students did the experiment in groups with two.
In Pendulum - experiment I we had four times a group of a girl and a

boy. In the Pendulum - experiment II we had two times a group of two girls and two times a group of two boys.

3. What can we learn by the experiments?

3.1 Our main interest was to observe the way students co - operate in these conditions.
By analizing the tape we saw remarkable differences in the co - operation of the two kinds of groups, we had made.

3.2 We give a résumé by making some tables. In table I we show the activities, being done by a girl (g) and a boy (b) in the different groups of Pendulum - experiment I.

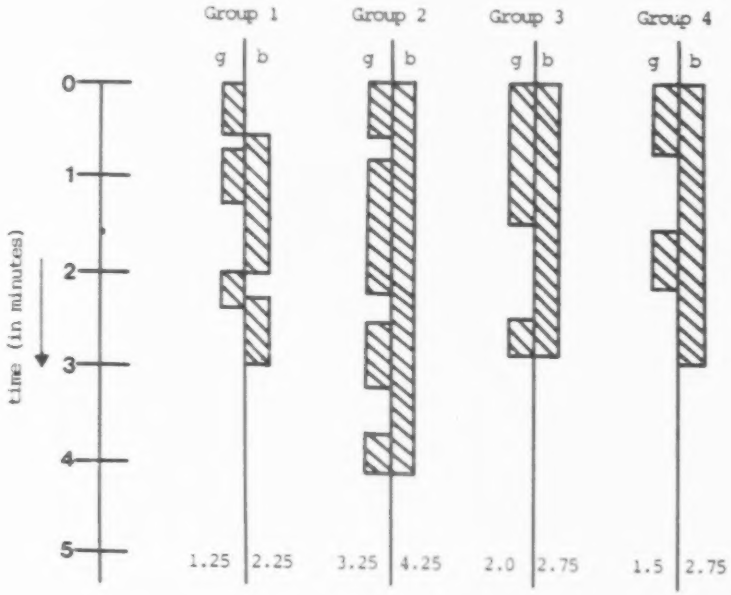
Table 1

Activities in the Pendulum-experiment 1

	Group 1	Group 2	Group 3	Group 4
read the instructions	g	g/b	quiet	b
fasten the weight	b	g/b	b	g/b
swing the pendulum	g	b	g	g
measure the pendulation-time	b	g/b	b	b
count the pendulations	g	b	quiet	g/b
measure the length of the pendulum	g	g	g	g
write the results on the blackboard	b	b	b	b

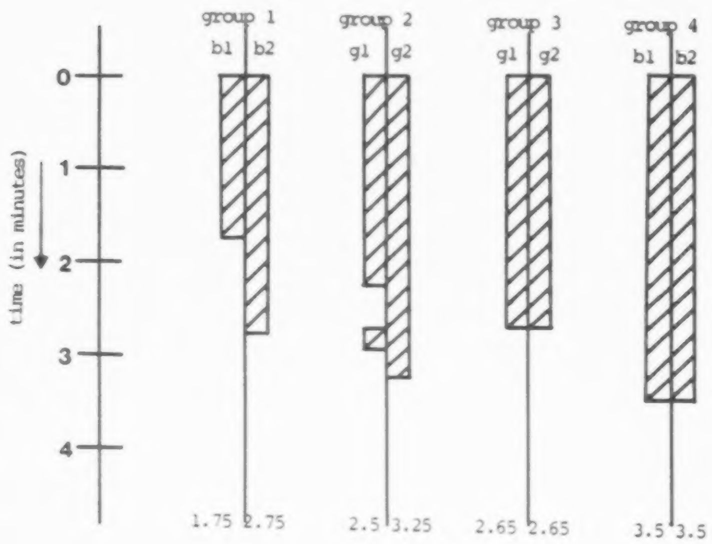
3.3 Table II is a time - table of the pendulum - experiment I. It gives us the time during which a boy (b) and/or a girl (g) were actually active in the experiment. At the bottom of this table one can see the total time of action during the experiment of each of the students.

Time-table Pendulum-experiment 1



3.4 Table III is the time - table of the pendulum - experiment II

Time-table Pendulum-experiment 2



3.5 We give two examples of the way students were talking during the experiments. One of pendulum - experiment I and one of pendulum - experiment II.

Example dialogue pendulum - experiment I

....

b. so, ...
we fasten the weight at it, ...
and fasten at the support, ...

g. so we fasten it at the support.

b. and let pendulate.

g. measure the time of 10 pendulations

b. now, ...

g. Do you know how a stopwatch works?
Let's think a moment, ...

b. .... yes, let him till four, hm,
average,............

g. hé, can't it to zero?

b. No, look .... So. And then push it in here.

g. hm, ... ten pendulations?

b. Yes, then start we now, Push in, 1,.. 2,.. 3,.. 4,.. 5,.. 6,.. 7,..
8,.. 9,.. 10,..
Stop now!

g. hm,.......

b. Longer than a minute?

g. No, not sŏ long, hm, 13 seconds,......
13.4 seconds.........

b. 13.4 seconds.

g. How long is one pendulation?

b, How long is one pendulation?
Yes, we have to take that, ... so ....
hm, ..., what shall we do now?
.... yes, pendulate.

g. Almost two seconds.

b. Almost two seconds.

g. Measure the length of the pendulum

b. ..... wait a moment, I think we have to do it different, hm,.....
pendulum, ... yes, the length of the pendulum, that's namely
the string, ... must we, ... pendulum, ... hm; now,hm,....
...... let's look a moment,.......

g. Has it to pendulate that way?

b. yes.

g. hm,

b. how far can it reach

g. oh, ... yes? ..... oh?

b. yes, ... oké, how far can it reach.

g. oh, ... hm,....

b. off for a moment.

g. wait a moment.

b. yes,.....

g. so far, approximately, ...7......

b. 47 cm., ... 47 cm.......... now,.........

g. write down.

b. shall I do this,...... oké.

g. It was precisely 1.8.

b. Precisely 1.8?

g. Yes.

b. And the length of the pendulum was?

g. 47cm.

b. 47cm? ..... so, that's finished, .. so, hm....

Example dialogue pendulum - experiment II (two girls)

....

g2. that's finished.

g1. after that, fasten the string at the support.

g2. How long ten pendulations last, hey.
Take it!

g1. How long ten pendulations are, hey?

g2. Yes, 1,2,3, ... stop,..

g1. It must be that way, that's once?

g2. hm......

g1. yes, ...

g2. .... hm, let's start again, ...
ho, one pendulation is that way........
..... one ...... 1,.. 2,.. 3,.. 4,.. 5,.. 6,.. 7,.. 8,.. 9,.. 10,..
7.5 minutes, oh seconds.

g1. 7 seconds.

g2. 7.5 seconds, that is 7 seconds, isn't it?
.... Do you know how a stopwatch works?

g1. yes,

g2. ha...ha...

g1. How long is one pendulation?

g2. Do it now,.....
if you just........
1, 2 .... yes ...... 1 .....
hey, you made a mistake!
you must 1, 2, ...

g1. oh,.....

g2. 1, yes....yes....measure the length of the pendulum.

g1. ....54 cm. ....

g2. take the piece of paper with you!

g1. the time of pendulation was 0.6 ....

g2. now, the length of the pendulum!

g1. ready ....

4. Conclusions

As is shown in table I we can make the following conclusions:

a) In all cases the measuring of the length of the pendulum is done by the girl. The pendulum - time mostly has been measured by the boy.

b) In all cases it is the boy who writes the results on the blackboard. As is shown by table II.

c) The co - operation in the pendulum - experiment II is closer than in the pendulum - experiment I (see table II and III).

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21. INFORMING CHILDREN ABOUT SCIENCE AND TECHNOLOGY: SOME SUGGESTIONS AND PRACTICAL ATTEMPTS

As a starting point for my discussion I will present a pilot study about science information to children. With this study as a background and referring mostly to my own experiences, I make some suggestions on how to make children and especially girls interested in science and technology. Finally I present some concrete projects from the educational field in Sweden.

During the last years there has been a growing interest in science information in Sweden - that is information to the public about science and technology. This includes information about ongoing research, ways of making people somewhat familiar with different ways of carrying out research and on the whole more open to discuss and evaluate the aims and products of research. Thereby people should better understand what researchers do in order to be able to follow current debates in society actively and critically.

Swedish universities also have an obligation to spread information about research, the results and how these results may be applied.

One important aspect is information to children and young people and in a wider meaning ways of stimulating their interest in these matters. This is a concern of high priority for The Council for Planning and Coordination of Research (Forskningsrådsnämnden) which belongs to the Ministry of Education and has a special delegation for science information.

A pilot study on science information to children

One year ago some collequages and I carried out a pilot study to explore how children think and feel about research and science. Initially the study was made to give us some back-

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ground data for a radio program with children and scientists discussing research. We got so interested, however, that the study got somewhat more comprehensive than was meant from the beginning. Since I think it may give a good starting-point for my discussion I will relate it in some detail.

Setting out from questions concerning children's image of the future - I was at the time engaged in research on the role of school in preparing children for the future and besides, we thought the approach would be a fruitful one - we drew up the following general problem areas.

- How do children imagine the future?
- In what ways can children's activity and imagination be stimulated and how can we help them to influence their future?

These questions could be connected to research and science information in a rather natural way:

- Which areas of research have points in common with children's reality experiences? What is exciting and important to them and what interests can be roused?
- Is it possible to inform children about science and research in a manner so as to stimulate their curiosity and activity?
- Which ideas for research and solutions to problems can children contribute with themselves?

Our study was supposed to give us a first idea of children's image of the future together with suggestions to research in the future.

10-11-year old children from 10 school-classes from different parts of Sweden were asked to draw a picture and write an essay on the subject "Future in the year 2000". We also visited the classes and talked with the children. During these sessions we wanted the children to express themselves rather freely, but the discussions were kept along the following lines:

- What do you think future will be like?
- What can we do to make future the way we want it to be?
- What kind of research would you like scientists to carry out?

The taped group discussions as well as the drawings and essays were content analyzed according to their main themes.

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This study is to be seen as an exploration of a comparatively new field. Above all we wanted to get ideas and inspiration for further science information work but also the new experience of meeting young people in our role as scientists. In my original report about the study I call the results a "bank of ideas", which may be used in further discussions about science information or inspire to more elaborately designed studies. (For the moment Swedish TV is discussing a program based on the data.)

A summary of our main observations can be stated as follows: The meaning of "research" was usually explained by the children by terms like "to invent things", "to get to know more", "to find solutions to problems".

The most important research objects for these children were without question problems concerning environment and pollution, energy supplies in the future, the technological society and its consequences, violence and war. These themes have been dealt with in all the classes with great emphasis. Scientists have to invent ways to keep the world clean and free from pollution, they must find alternate renewable energy sources and investigate and prevent dangerous consequences of technology. This usually meant unemployment which was a familiar and bitter experience to many of our children. War is a frightening and recurrent theme too. To the children it is absurd that scientists should canalize their energy and intelligence into research on deadly weapons. Surely, the only logical and human research object would be to solve the food problem in the world, thereby helping people to survive.

We almost never experienced any positive attitudes toward technological progress. Although some children expressed vivid fantasies about beautiful and super-strong motor-cars and fanciful household machines, these fantasies mainly seemed to belong to a world of science fiction which they were somewhat embarrassed to talk about. Interest in space research which was expected to be great according to the popular stereotype of these years did not turn out to be a very common subject either.

There seemed to be a great fear of the world being overtaken by computers and robots, while people get more and more superfluous, as well as a fear of the impassiveness and loss of feelings expected as unavoidable consequences.

Some pupils would like to know more about why people act the way they do. And why they think what they think. Which are the influencing forces? What significance do war-toys and violent films have, for example?

Thoughts about our common responsibility for the future stood out in heavy contrast, however, to the feelings of pessimism and powerlessness that the children so often expressed. In their eyes there seemed to be a very large gap indeed between "those who know and decide everything" and the little ordinary human being. They think that they have the right to affect their situation and their future, but they do not know how and they think they never will. Results very similar to ours have been described in other Swedish studies as well (Berg & Holm, 1979; Brodow, 1980; Hartman, Petersson & Westling, 1973; Statens ungdomsråd, 1980).

However, in addition to the problem areas which our children gave a high priority for research, they also contributed themselves by suggesting solutions to specific problems. So I will give this section a positive finish by relating some examples:

- Scientists should find ways to create synthetic ozon, which can be shot up into the air and replace the ozon layer which is on the way of being destroyed. (This suggestion made a great impression on the visiting scientist.)
- Smoke from industries should be made clean by means of a special chimney filter.
- We should use a lot of turf and wood for energy, therefore we should invent a special stuff for the trees to grow faster.
- Metal bars which are made to glow in the hot sun should be able to transfer the heat to other places where the heat is really needed. Just fancy the Sahara partly filled with these glowing metal bars!
- Underground housing would be a help in solving problems

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connected with the population explosion and at the same time leave more room for agricultural purposes.
- If we could find a common world-wide language, we would understand each other better and the risk of war would decrease.

Some conclusions

In the discussion to follow I will take what may be called an activating future perspective. Basic for me is the wider question of how children can be activated to take a responsibility for their situation now and in the future. Since women so far have been most disadvantaged in influencing their conditions (e.g. economically, socially, politically) it comes natural that I give girls special attention. In this connection I will also primarily stress the technological aspects.

- Our study gave us some information about problem areas that are especially important to the children. So we can expect questions like these to be fruitful objects for treatment in the classes, as starting-points for discussions and information about science in a wider meaning.
- When discussing different problem areas the children show evidence of cross-disciplinary thinking and they often use material from their own experiences, their own reality.
- The majority of the children seem very aware of their situation and their future and more critical and analyzing then adults perhaps usually expect. Many times the teachers in our study came to us afterwards to tell us how much the quality of the children's opinions had astonished her/him.
- Since the developments of science and technology have to be evaluated in a long term perspective, the image of the future is relevant for the children as well as for all of us. We have to ask what kind of future society we really want.

Focussing on the girls

Boys' and girls' different traditions and experiences also affect their image of the future (Dahlgren, 1977; Lindholm,

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1980). An earlier study carried out within the project "Preparedness for the future" indicated for example that more boys than girls thought about the technological aspects of future and put very little stress on human beings, while the girls more often described the everyday social and human situation (Jönsson, Persson & Tvingstedt, 1979). Pauline Barts writes in an article about the traditional sex roles and their restricting impact on children's future images (1974). Stressing especially the situation for girls, she writes: "The repeated false assertion that history was essentially a male affair suggests to the unwary that the same will hold true of the future." (P. 38.) This quotation brings us closer to the female situation.

So far masculine values have been the ones that count in society. This facilitates boys' and men's identification with and acceptance of the values upon which technological society is built. Female values are desperately needed in the reproductive sector at home, outside they really do not count. Therefore technology may seem strange and also frightening to many a girl. Since she does not feel at ease with many aspects of the masculine world the danger is, however, that she abandons the idea of having anything to do with it at all. It becomes none of her business, she cannot change anything anyway.

By stimulating girls to take an interest in technology, however, we try to give them more power to influence their future and in a wider sense that of society as well. They will find more ways of making personal careers thereby using more of their personal capacity. Society will be benefitted by intellectual and emotional resources which up till then have been almost invisible.

How then can we help girls to understand that the technological development is also their business to a very high degree?

From my perspective I have some suggestions:

- There has to be a basic recognition among the teachers of girls' rightful place in technology. Their experiences must be accepted and given the same status as those of boys. An open and questioning attitude in the girls has to be en-

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couraged. Girls must feel that they are welcome and needed in the field, that they have very important contributions to make which have been made invisible too long and - not the least important - a great responsibility to shape the future society.

— Turning to the more concrete aspects of school-work, textbooks with female models should increase the possibilities for girls' identification as well as make boys to get used to the sight of women in untraditional roles. Formulations of problems should appeal to girls' experiences as well as to those of boys.

- There has to be discussions of the consequences of different applications of technology in relation to the kind of future boys and girls want. Here it is important that boys and girls work together - and this must never mean that girls always have to carry out the routine tasks while the planning is saved for the boys - in order to understand each other's frame of reference better. This may imply a problem-oriented approach which goes across the traditional discipline borders and involves the participation of several teachers on the specific problem areas studied.

Some illustrative examples of projects

According to the new Swedish Curriculum Plan for the compulsory school which is to be completely in use from the autumn term of 1982, studies in the natural sciences and technology are going to be non-optional through the whole obligatory nine-year school. In time this will have consequences for our teacher education. The Swedish Board of Education has initiated a special project with the aim of giving in service primary and middle stage teachers continuing education in this respect. Consistent with the Curriculum Plan this project recommends a laborative approach which also considers the children's own experiences. It is also important that the children are stimulated to express their observations in many different ways, by painting and drawing for example.

Last term I worked as an educational consultant in a science course for children at the University of Lund[1]. 10-12-year old children met investigators at the university, listened to presentations of their respective expert fields, learnt a little about ongoing research and tried some simple experiments. A common observation was that the girls seemed at least as interested and ambitious as the boys. Children's own questions were encouraged, since the communicative aspect of science information was stressed like it was in the study first mentioned in this paper. The children had note-books, "research books", where they wrote down the observations they made.

The theme for the course was "Get to know your town and its surroundings". The children were introduced to geology ("The ground below"), to biology ("Plants and trees in our town"), architecture ("The houses in our town"), and physics ("The air above"). The experiences from the course have been very positive. Many teachers have asked for a similar course for themselves. A new course is planned during this school-year.

Natural and spontaneous contacts between scientists and children must be very helpful in breaking down stereotyped and even suspicious attitudes toward scientists and research. Such contacts may also stimulate the teachers to a greater interest in these kinds of activities in their daily class-room work. The model value for girls of contacts with female investigators has to be especially pointed out.

For two years now, special efforts have been made by a project group at the High School of Technology in Lund to enroll more girls. With financial help from the University Commitee for Equality (where I am the permanent secretary) a three-day "mini-course" for girls has been held during the spring term. The girls are natural science or technology students in the gymnasium and about to choose post-gymnasium education[2].

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[1] Initiators to the course were a university professor in physics, Bengt Forkman, and his wife, Barbro Forkman.

[2] The project is led by Ms Ragna Ehrenstråhle at the High School of Technology in Lund.

Finally I *plan a study* to investigate which conditions are available in a Swedish community to stimulate children's interest in science and research. We want to get an idea of the children's interests and preferences and what resources an ordinary community have to meet them. These efforts should probably be integrated within the ordinary school curriculum as well as the leisure time activities organized by the community if the strivings should have long term positive effects.

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